

CHAPTER 2 SELF-QUIZ

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1. False: Polymers such as nylon are formed from monomer subunits that may be identical or may be different.
2. True
3. True
4. False: Amino acids contain a carbon atom attached to a carboxyl group and an amino group.
5. False: Starch and cellulose are polysaccharides of the monosaccharide glucose; sucrose is a disaccharide of glucose and fructose.
6. (d)
7. (d)
8. (b)
9. (e)
10. (c)
11. (d)
12. (b)
13. (b)
14. (a)
15. (c)

CHAPTER 2 REVIEW

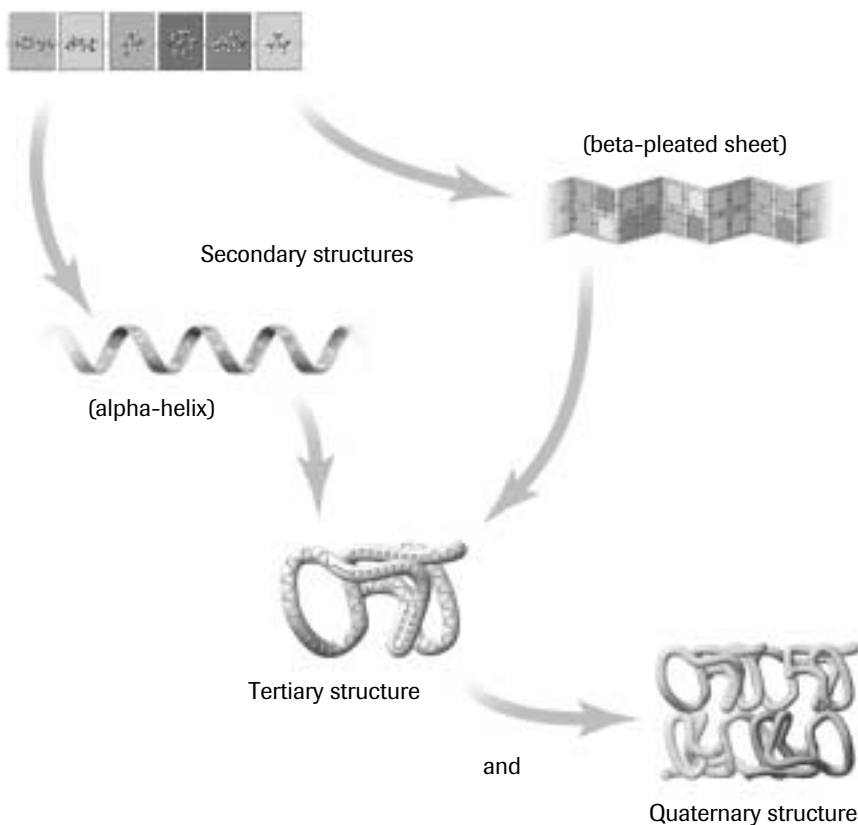
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Understanding Concepts

1. $\text{CH}_2=\text{CH}_2\text{CN}$
2.

$$\begin{array}{c} \text{O} \qquad \qquad \text{O} \\ \parallel \qquad \parallel \\ [-\text{OCHC}-\text{OCHC}-] \\ | \qquad \qquad | \\ \text{CH}_3 \qquad \text{CH}_3 \end{array}$$
3. (a) Crosslinking restores the polymer strands to their original position, after any stretching or other deformation; this makes the polymer elastic.
(b) For crosslinking to occur, a monomer must be able to form bonds other than the bonds forming the polymer chain itself; that is, it must have an additional functional group (e.g., double bond, hydroxyl group, carboxyl group), other than the two involved in the polymer linkages, to link with another polymer chain.
4. (a) There will be hydrogen bonding between the hydroxyl group and the carbonyl group, both intrachain and interchain. The molecule may have a helical structure.
(b) There will be little bonding interaction within the same chain, although the molecules can form crosslinkages between chains from addition reactions of the double bond. The polymer may have a strong elastic structure.
(c) There will be hydrogen bonding between the amino group and the carbonyl group, both intrachain and interchain. The molecule may have a helical structure.
5. (Model-building exercise)
6. (a) (Model-building exercise)
(b) This compound will be a condensation polymer. The carboxyl groups can react in condensation reactions with a monomer with two hydroxyl groups or two amino groups. There are no double bonds to form an addition polymer.

7. (a) Primary structure



(b) Primary structure, the amino acid sequence, determines the type and position of intrachain interactions, thus determining the secondary structure, coils, or pleated sheets. The secondary structure determines the sections of the protein that can fold into globular shapes, or align to form fibrous proteins. These structural features determine the solubility, mobility, and strength of the proteins, and thus their function. Quaternary structure describes the grouping together of several protein molecules into a larger unit, allowing for more complex protein function.

8. (a) For energy storage and energy source. Helical structure allows starch to be easily transported and readily available in an organism.

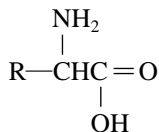
(b) For plant structure. Linear molecules allow close alignment for strength and rigidity, as well as being insoluble in water, properties ideal for building plant structure and support.

(c) For energy storage and energy source in animals. Helical structure allows glycogen to be easily transported and readily available in an organism.

9. (a) $\text{C}_{12}\text{H}_{22}\text{O}_{11} + 12 \text{O}_2 \rightarrow 12 \text{CO}_2 + 11 \text{H}_2\text{O}$

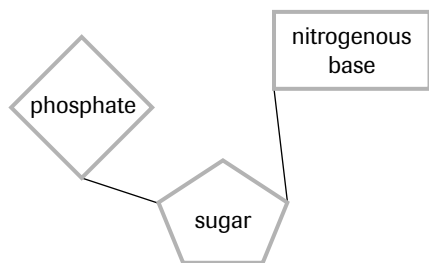
(b) $\text{C}_{12}\text{H}_{22}\text{O}_{11} + \text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + \text{C}_6\text{H}_{12}\text{O}_6$
glucose fructose

10. (a) Proteins are made up of amino acid monomers, each of which contains a carbon atom with an attached carboxyl group and an attached amino group.



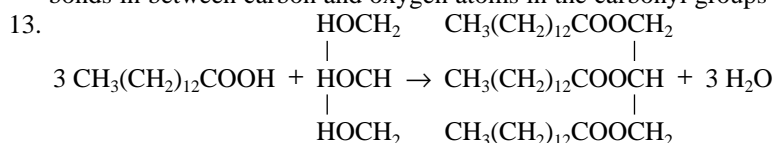
amino acid

- (b) DNA is made up of nucleotides, each of which contains a phosphate group, a deoxyribose group, and one of four nitrogenous bases.

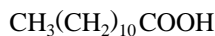


DNA monomer

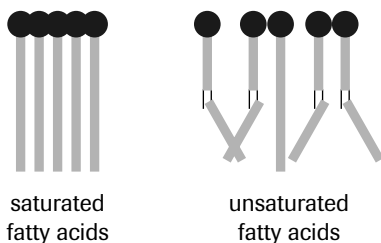
11. (a) hydroxyl groups; condensation reaction
 (b) hydroxyl and carboxyl groups; esterification reaction
 12. There are carbon-carbon double bonds in the hydrocarbon portion of the fatty acid chains. There are also double bonds in between carbon and oxygen atoms in the carbonyl groups in the ester linkages.



14. (a) $\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$



- (b) It is likely an oil at ordinary room temperatures because it is unsaturated.



15. (a) The fats in lard contain fatty acids that have a large hydrocarbon component; thus, they burn with amounts of heat released similar to those of burning hydrocarbons. Table sugar is sucrose, which is a carbohydrate and does not release as much heat as hydrocarbons do.
 (b) We do not have the enzymes specific to breaking down the cellulose molecules in paper and thus cannot derive any energy from ingesting paper. When paper is burned, the cellulose molecules are oxidized to carbon dioxide and water, with a release of energy.

Applying Inquiry Skills

16. (a) Softening on heating: If polymer chains are held together by weak van der Waals attractions, the energy from heating weakens the attractions, and the polymer softens. If crosslinking is present, the polymer does not readily soften on heating.
 (b) Softening in acetone: Polymers containing carbonyl groups tend to be softened by acetone as this organic solvent also contains a carbonyl group.
 (c) Strength and rigidity, flame test with copper wire: The strong carbon-halogen bonds make the polymer very strong and chemically unreactive. When a hot copper wire is pressed into the polymer, a green flame indicates the presence of halogen atoms (which forms a halide ion of copper that produces the flame colour).
 17. (a) Detergent has a polar end and a nonpolar end, and thus dissolves the fatty molecules as well as itself dissolving in the water molecules.

- (b) Heating the DNA weakens the hydrogen bonds holding each DNA strand in a tightly coiled helix, as well as the hydrogen bonds holding the two strands together in the double helix.
- (c) Cooling solidifies the dissolved fat and protein contaminants, so that they can be removed in the next step. It also stops possible denaturation of the DNA.
- (d) DNA is soluble in water by virtue of its many polar phosphate groups which form its backbone. While ethanol has a hydroxyl group which makes it soluble in water, the presence of its methyl group makes it more nonpolar than water. DNA is thus insoluble in this less polar solvent.

18. (Sample answer)

Experimental Design

Compare the viscosity of the two oils at different temperatures. The less saturated oil likely has weaker intermolecular forces, and thus would be less viscous.

Materials

2 large test tubes with rubber stoppers
marbles of equal size and mass
hot-water bath
timer
thermometer

Procedure

1. Place a marble in each test tube. Fill one labelled test tube with olive oil and the other with coconut oil. Stopper securely.
2. Invert the two test tubes, and record the time taken for the marble to travel to the bottom of the tube.
3. Place the tubes in the hot-water bath and raise the temperature of the test tubes and oils by 5°C.
4. Repeat the procedure for timing the marble. Repeat for several temperature increases.

Analysis

If there is a difference in time taken for the marble to travel down the two different oils, the faster time indicates the less viscous oil, which indicates the more unsaturated oil.

Making Connections

19. (Sample answers)

Synthetic polymer	Use	Monomer	Type of reaction
polyethene	fabrics	ethene	addition reaction
polypropene	rope	propene	addition reaction
polystyrene	foam cups	styrene	addition reaction
nylon	fabrics	dicarboxylic acids and diamines	condensation reaction
Dacron	fabrics	dicarboxylic acids and diamines	condensation reaction

20. (Sample answer) Nylon is a synthetic polymer similar to the natural polymer, silk. Nylon is stable, strong, easy to care for, and affordable. Nylon is made from petroleum products from nonrenewable sources, and is nonbiodegradable.

Cotton was the inspiration for polyester. Polyester is strong, wrinkle-free, and affordable; cotton is more comfortable to wear and is made from renewable materials; polyester is made from petroleum products from nonrenewable sources, and is nonbiodegradable.

Sugar is sweet; so is aspartame. However, sugar is high in calories and linked to tooth decay; aspartame may be linked to health risks, and has an aftertaste. Diabetics cannot ingest sugar but can use aspartame for sweetening foods.

21. (a) Plastic is stronger because it can be designed with strong crosslinkages between the polymer strands. Paper is made of cellulose which are fibrous strands of glucose polymers; the crosslinkages may not be as strong as in plastics.
- (b) Paper may be more quickly decomposed by bacteria which contain enzymes to hydrolyze cellulose. Plastics do not readily break down as this would require the breaking of the covalent bonds holding the monomers together.
- (c) (Sample answer) Paper bags are correctly labelled as organic (as they are made of molecules containing carbon atoms), as natural (as they are made from wood, made by plants), and as chemical (molecules are made of elements). Plastic bags are correctly labelled as organic (made of molecules containing carbon atoms), not as natural (because synthesized in a laboratory or factory), and as chemical (made from chemicals). In general usage, the term “natural” may be applied to paper bags and the term “chemical” to plastic bags.

22. (a) Flour, cork, and jute are plant materials that are mainly cellulose; as these are main ingredients of linoleum, it may be classified as a polymer. All the ingredients are natural; all except the limestone dust are synthesized by living organisms and thus may be classified as organic (carbon-containing compounds). All matter is composed of chemicals, so the linoleum is also chemical.
- (b) The linseed oil, a major ingredient, is a mixture of oils that are esters of fatty acids and alcohols. These ester linkages can be hydrolyzed by strong bases such as high pH cleaning agents, in saponification reactions.
- (c) Advantages: easily decomposed, atoms in materials are recycled when decomposed, does not require nonrenewable resources.
Disadvantages: the linoleum floor is vulnerable to attack by bacteria or mould, can readily decompose if conditions such as moisture are not controlled, and it is not long-lasting or durable.
- (d) You might want to consider such factors as:
is it a high-traffic area?
is it likely to remain damp for extended periods?
appearance
availability
cost
23. (a)
$$\begin{array}{c} \text{O} \qquad \text{NH}_2 \\ || \qquad | \\ \text{H}_2\text{NCCCH}_2\text{CH}_2\text{CHCOONa} \end{array}$$
- (b) Yes. Carbon 2 is attached to 4 different groups or atoms: H, NH₂, COONa, and CH₂CH₂C(O)NH₂. It is, therefore, a chiral molecule.
- (c) There is some evidence that a small portion of the population experiences mild reactions to MSG. These are not classified as allergies, but as a sensitivity or intolerance; they include: effects to the heart, respiratory tract, muscles, eyes, skin, gastrointestinal tract, circulation, and neurological functions. Drinking alcohol or exercising just before or after ingesting MSG may increase the intensity of the adverse reaction.

UNIT 1 PERFORMANCE TASK: CHEMISTRY IN A BATHTUB

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1 Research, Plan, and Synthesize an Ester

Experimental Design

- (a) (Answers may vary. Sample answer) Ethyl butanoate is one ester which could be synthesized. It has a pineapple flavour.
- (b) Butanoic acid + ethanol → ethyl butanoate

$$\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH} + \text{CH}_3\text{CH}_2\text{OH} \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{COOCH}_2\text{CH}_3 + \text{H}_2\text{O}$$

 Butanoic acid is heated with ethanol, in the presence of concentrated sulfuric acid as a catalyst, to produce ethyl butanoate. A water molecule is also produced in this condensation reaction, called esterification. As the ester has a low solubility in water, it can be extracted from the reaction mixture by adding the mixture to water and removing the layer of ester floating on the water surface.

Materials

- (c) ethanol
 butanoic acid
 concentrated sulfuric acid
 2 test tubes
 hot-water bath (large beaker of water over hot plate)
 hot plate
 pipette and suction bulb
 evaporating dish
 eyedropper

Safety Precautions

Eye protection and a lab apron must be used at all times. Also, conduct experiment in a fume hood.