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| **Chemistry 23.1**  **Introduction to Functional Groups**  **From a distance, the musicians in an orchestra may look alike, but each musician contributes a unique sound. In a similar way, one hydrocarbon is nearly identical to another until it picks up a functional group. You will learn how functional groups determine the character of organic compounds.**  **Functional Groups**  **How are organic compounds classified?**  **Organic compounds can be classified according to their functional groups.**   * + - * A **functional group** is a specific arrangement of atoms in an organic compound that is capable of characteristic chemical reactions.   The hydrocarbon skeletons in the components of these products are chemically similar. Functional groups give each product unique properties and uses.  **Halogen Substituents**  **What is a halocarbon?**   * + - * **A halocarbon is a carbon-containing compound with a halogen substituent.**       * **Halocarbons** are a class of organic compounds containing covalently bonded fluorine, chlorine, bromine, or iodine.       * On the basis of their common names, halocarbons in which a halogen is attached to a carbon of an aliphatic chain are called **alkyl halides.**       * Halocarbons in which a halogen is attached to a carbon of an arene ring are called **aryl halides**.   The figure below shows the IUPAC names, structural formulas, and space-filling models for three simple hydrocarbons.  **Substitution Reactions**  **How may halocarbons be prepared?**  A common type of organic reaction is a **substitution reaction**, in which an atom, or a group of atoms, replaces another atom or group of atoms.   * + - * A halogen can replace a hydrogen atom on an alkane to produce a halocarbon.   **A Generalized Equation and a Specific One**  Treating benzene with a halogen in the presence of a catalyst causes the substitution of a hydrogen atom in the ring.  Halogens on carbon chains are readily displaced by hydroxide ions to produce an alcohol and a salt. The general reaction is as follows.  Halocarbons also undergo substitution reactions.  **Chemistry 23.2**  **Alcohols and Ethers**  **A patient does not experience pain during surgery when given a general anesthetic. The earliest anesthetics, used during the Civil War, belonged to a class of chemical compounds called ethers. You will read about the chemical characteristics of ethers that make them good anesthetics.**  **Alcohols**  **How are alcohols classified and named?**   * + - * An **alcohol** is an organic compound with an — OH group.       * The —OH functional group in alcohols is called a **hydroxyl group** or hydroxy function.   **Aliphatic alcohols can be classified into structural categories according to the number of R groups attached to the carbon with the hydroxyl group.**  **When using the IUPAC system to name continuous-chain and substituted alcohols, drop the -*e* ending of the parent alkane name and add the ending -*ol*.**  Alcohols can have more than one hydroxyl group. These alcohols contain one, two, or three hydroxyl groups. Ethanol (ethyl alcohol) is a common component of many household products. Aliphatic alcohols are used in many household products, including antiseptics, antifreeze, and cosmetics.  **How does the solubility of an alcohol vary with the length of its carbon chain?**  **Alcohols of up to four carbons are soluble in water in all proportions. The solubility of alcohols with four or more carbons in the chain is usually much lower.**  **Fermentation** is the production of ethanol from sugars by the action of yeast or bacteria. A second reaction product, carbon dioxide, causes bread to rise.  Ethanol is the intoxicating substance in alcoholic beverages. It is a depressant that can be fatal if taken in large doses at once.   * + - * **Denatured alcohol** is ethanol with an added substance to make it toxic (poisonous).       * Denatured alcohol is used as a reactant or as a solvent in industrial processes.   **Addition Reactions**  **What reactions of alkenes may be used to introduce functional groups into organic molecules?**  **Addition reactions of alkenes are an important method of introducing new functional groups into organic molecules.**  In an **addition reaction**, a substance is added at the double or triple bond of an alkene or alkyne. Double and triple bonds between carbon atoms are much more reactive than single bonds between carbon atoms.  **Addition Across a Double Bond**  The addition of water to an alkene is a **hydration reaction.**  The addition of hydrogen to a carbon–carbon double bond to produce an alkane is called a **hydrogenation reaction.**  **Ethers**  **What is the general structure of an ether and how are the alkyl groups of an ether named?**  **The general structure of an ether is R—O—R. The alkyl groups attached to the ether linkage are named in alphabetical order and are followed by the word *ether*.**  An **ether** is a compound in which oxygen is bonded to two carbon groups.  **Chemistry 12.3**  **Carbonyl Compounds**  **Have you heard of benzaldehyde or vanillin? It is likely that you have eaten these organic molecules, called aldehydes, in ice cream or cookies. You will read about the properties that are associated with carbonyl compounds, such as aldehydes.**  **Aldehydes and Ketones**  **What is the structure of a carbonyl group found in aldehydes and ketones?**  A **carbonyl group** is a functional group with the general structure C═O.   * + - * The C═O functional group is present in aldehydes and ketones.   An **aldehyde** is an organic compound in which the carbon of the carbonyl group is always joined to at least one hydrogen.  A **ketone** is an organic compound in which the carbon of the carbonyl group is joined to two other carbons.  **Properties of Aldehydes and Ketones**  **Uses of Aldehydes and Ketones**  Many aldehydes and ketones have distinctive odors.   * + - * Aromatic aldehydes are often used as flavoring agents.       * Benzaldehyde is known as oil of bitter almond.       * Cinnamaldehyde is the source of the odor of oil of cinnamon.   Vanillin, an aldehyde, comes from vanilla beans.  A solvent used to remove nail polish is acetone, a ketone.  **Carboxylic Acids**  **What is the general formula for a carboxylic acid?**   * + - * A **carboxyl group** consists of a carbonyl group attached to a hydroxyl group.       * A **carboxylic acid** is a compound with a carboxyl group.   **The general formula for a carboxylic acid is RCOOH.**   * + - * Carboxylic acids are weak because they ionize slightly in solution to give a carboxylate ion and a hydrogen ion.   Carboxylic acids give a variety of foods—spoiled as well as fresh—a distinctive sour taste.   * + - * Low-molar-mass carboxylic acids are volatile liquids with sharp, unpleasant odors.       * The higher-mass carboxylic acids are nonvolatile, waxy, odorless solids with low melting points.       * Many continuous-chain carboxylic acids were first isolated from fats and are called **fatty acids.**       * Stearic acid, an 18-carbon acid obtained from beef fat, is used to make inexpensive wax candles.   **Esters**  **What is the general structure of an ester?**  **Esters contain a carbonyl group and an ether link to the carbonyl carbon. The general formula for an ester is RCOOR.**  **Esters** are derivatives of carboxylic acids in which the —OH of the carboxyl group has been replaced by an —OR from an alcohol.  Esters may be prepared from a carboxylic acid and an alcohol.  Ethyl ethanoate is a low-molar-mass ester.  **Chemistry 12.4**  **Polymerization**  **Snap beads are a favorite toy for toddlers. Chemical compounds called monomers and polymers resemble snap beads. Monomers are joined end-to-end to form long chains called polymers. You will learn about monomers and polymers.**  **Addition Polymers**  **How does an addition polymer form?**   * + - * A **polymer** is a large molecule formed by the covalent bonding of repeating smaller molecules.       * The smaller molecules that combine to form a polymer are called **monomers**.   **An addition polymer forms when unsaturated monomers react to form a polymer.**  Polyethylene is used to make many household items, including plastic bottles, bags, and food containers.  Polypropylene, a stiffer polymer than polyethylene, is used to make plastic utensils and containers, and other items such as this whistle.  Polypropylene is prepared by the polymerization of propene.  Polystyrene foam is a poor heat conductor, useful for insulating homes and for molded items such as coffee cups and picnic coolers.  Polyvinyl chloride (PVC) is used for pipes in plumbing. It is also produced in sheets, sometimes with a fabric backing, for use as a tough plastic upholstery covering.  Polyvinyl chloride (PVC) is a halocarbon polymer. Vinyl chloride is the monomer of polyvinyl chloride.  Polytetrafluoroethene (Teflon™or PTFE) is the product of the polymerization of tetrafluoroethene monomers.  PTFE is very resistant to heat and chemical corrosion. It is used to coat cookware and to insulate wires, cables, motors, and generators.  Rubber is harvested from tropical plants and is used in a variety of products.  Polyisoprene, harvested from tropical plants such as a rubber tree, is the polymer that constitutes rubber.  **Condensation Polymers**  **How are condensation polymers formed?**  **Condensation polymers are formed by the head-to-tail joining of monomer units.**  Polyesters are made by linking dicarboxylic acids and dihydroxy alcohols. The polyester polyethylene terephthalate (PET) is formed from terephthalic acid and ethylene glycol.  Woven Dacron (PET fibers) tubing can be used to replace major blood vessels.  Polyamides are polymers in which the carboxylic acid and amine monomer units are linked by amide bonds.  The representative polymer unit of nylon is derived from 6-aminohexanoic acid, a compound that contains both carboxyl and amino functional groups.  Nylon fibers are used for carpeting, tire cord, fishing lines, sheer hosiery, and textiles.  Kevlar™is a polyamide made from terephthalic acid and p-phenylenediamine.  Kevlar is used extensively where strength and flame resistance are needed. Bulletproof vests are made of Kevlar. |  |