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| **Chemistry 22.1**  **Hydrocarbons**  **Gasoline, diesel fuel, and kerosene are examples of liquid fuels. A solid fuel, coal, produced the steam for the locomotives that pulled old-time trains. These fuels are mixtures of compounds called hydrocarbons. You will learn about the structure and properties of hydrocarbons.**  **Organic Chemistry and Hydrocarbons**  **How is the number of valence electrons in carbon atoms related to the bonds that carbon atoms form?**  Because carbon has four valence electrons, a carbon atom always forms four covalent bonds.  **The simplest organic compounds contain only carbon and hydrogen and are called hydrocarbons.**  One carbon atom can form a single covalent bond with four hydrogen atoms.  **What are two possible arrangements of carbon atoms in an alkane?**  An **alkane** is a hydrocarbon in which there are only single covalent bonds.  **The carbon atoms in an alkane can be arranged in a straight chain or in a chain that has branches.**  **Straight-Chain Alkanes**  Ethane is the simplest of the **straight-chain alkanes**, which contain any number of carbon atoms, one after the other, in a chain.  A group of compounds forms a **homologous series** if there is a constant increment of change in molecular structure from one compound in the series to the next.  Hydrocarbons are used as fuels.  In a **condensed structural formula**, some bonds and/or atoms are left out of the structural formula. Although the bonds and atoms do not appear, they are there.  **Branched-Chain Alkanes**  An atom or group of atoms that can take the place of a hydrogen atom on a parent hydrocarbon molecule is called a **substituent**.  **A hydrocarbon substituent is called an alkyl group.**  **An alkane with one or more alkyl groups is called a branched-chain alkane.**  Ball-and-stick and space-filling models show the arrangement of atoms in 4-ethyl-2,3-dimethylheptane.  **Properties of Alkanes**  **In terms of their polarity, what type of molecules are alkanes?**  **Molecules of hydrocarbons, such as alkanes, are nonpolar molecules.**  The nonpolar molecules in the oil spill are not attracted to the polar water molecules in the ocean.  **Chemistry 22.2**  **Unsaturated Hydrocarbons**  **Roach traps are baited with pheromones, which roaches produce to attract mates. The structure of many pheromones is based on unsaturated hydrocarbons. You will study two types of unsaturated hydrocarbons—alkenes and alkynes.**  **Alkenes**  **What are the structural characteristics of alkenes?**  **At least one carbon-carbon bond in an alkene is a double covalent bond. Other bonds may be single carbon-carbon bonds and carbon-hydrogen bonds.**   * + - * Organic compounds that contain the maximum number of hydrogen atoms per carbon atom are called **saturated compounds.**       * Compounds that contain double or triple carbon-carbon bonds are called **unsaturated compounds.**   **Alkenes** are hydrocarbons that contain one or more carbon-carbon double covalent bonds.  Because rotation is restricted around the double bond, atoms in ethene lie in one plane.  **Alkynes**  **What are the structural characteristics of alkynes?**  At least one carbon-carbon bond in an alkyne is a triple covalent bond. Other bonds may be single or double carbon-carbon bonds and single carbon-hydrogen bonds.   * + - * Hydrocarbons that contain one or more carbon-carbon triple covalent bonds are called **alkynes.**       * Straight-chain and branched-chain alkanes, alkenes, and alkynes are **aliphatic hydrocarbons.**   The triple bond restricts rotation in an ethyne molecule, which has a linear shape.  **Chemistry 22.3**  **Isomers**  **The retinal molecule in the rod and cone cells of your eye has a hydrocarbon skeleton. When light strikes a cell containing retinal, it causes a change in the three-dimensional structure of the retinal molecule. The structures before and after the light strikes are examples of isomers. You will study different types of isomers.**  **Structural Isomers**  **How do the proerties of structural isomers differ?**  Compounds that have the same molecular formula but different molecular structures are called **isomers.**   * + - * Structural isomers differ in physical properties such as boiling point and melting point. They also have different chemical reactivities.   **Structural isomers** are compounds that have the same molecular formula, but the atoms are joined together in a different order.  Both butane and 2-methylpropane have the molecular formula C4H10. The atoms in their molecules are arranged in a different order, so they are structural isomers.  **Stereoisomers**  **What are the two types of stereoisomers?**  Two types of stereoisomers are **geometric isomers** and **optical isomers**.   * + - * **Stereoisomers** are molecules in which the atoms are joined in the same order, but the positions of the atoms in space are different.   **Geometric Isomers**  **Geometric isomers** have atoms joined in the same order, but differ in the orientation of groups around a double bond.  In the ***trans* configuration**, the methyl groups are on opposite sides of the double bond.  In the ***cis* configuration**, the methyl groups are on the same side of the double bond.  There is a *trans* and a *cis* configuration of 2-butene because a methyl group is attached to each carbon of the double bond.  **Optical Isomers**  A carbon with four different atoms or groups attached is an **asymmetric carbon.**  Pairs of molecules that differ only in the way that four different groups are arranged around a central carbon atom are called **optical isomers.**  **Chemistry 22.4**  **Hydrocarbon Rings**  **Beta-carotene is an important nutrient in carrots that also gives carrots their orange color. The hydrocarbon skeleton of beta-carotene contains hydrocarbon rings. You will learn about hydrocarbon rings and the properties of compounds formed from these rings.**  **Cyclic Hydrocarbons**  **What is the general structure of cyclic hydrocarbons?**  In some hydrocarbon compounds, the carbon chain is in the form of a ring.   * + - * Compounds that contain a hydrocarbon ring are called **cyclic hydrocarbons.**   **Three Ways to Represent Cyclic Hydrocarbons**  **What is the most accurate description of the bonding in a benzene ring?**  In a benzene molecule, the bonding electrons between carbon atoms are shared evenly around the ring.   * + - * An **aromatic compound** is an organic compound that contains a benzene ring or other ring in which the bonding is like that of benzene.   **The Structure of Benzene**  Benzene can be shown as switching, or resonating, between two arrangements of alternating double and single bonds.  **Aromatic Hydrocarbons**  The three symbols below can be used to represent the benzene ring. If the bonds are shown as alternating single and double bonds (on right), it is important to remember that bonds don’t actually alternate and that all six bonds are identical.  **Space-filling Model of Benzene**  **Substituted Aromatic Compounds**  Compounds with a substituent on a benzene ring are named as a derivative of benzene. When benzene is a substituent, it is called a phenyl group.  A benzene ring can have two or more substituents.  The molecules of many dyes include benzene rings.  **Chemistry 22.5**  **Hydrocarbons From Earth’s Crust**  **An artist imagines Saturn’s moon Titan as a refueling station in space. A traveler would refill a fuel tank with hydrocarbons from Titan’s atmosphere. On Earth, hydrocarbons are also used as fuels. You will learn about three fossil fuels—natural gas, petroleum, and coal.**  **Natural Gas**  **What type of hydrocarbons are in natural gas?**  Natural gas is an important source of alkanes of low molar mass.   * + - * The most important component of natural gas, methane, burns with a clean, hot flame.   Wells are drilled to reach natural gas and petroleum.  **Petroleum**  **What is the first step in the refining of petroleum?**  The refining process starts with the distillation of petroleum (crude oil) into fractions according to boiling point.   * + - * **Cracking** is a controlled process by which hydrocarbons are broken down or rearranged into smaller, more useful molecules.   Refineries separate crude oil into various components.  In fractional distillation, the crude oil is heated so that it vaporizes and rises through the fractionating column. The column is hotter at the bottom and cooler at the top.  **Coal**  **How is coal classified?**  Coal is classified by its hardness and carbon content.   * + - * Hardness of coal tends to increase with higher carbon content.   Lignite ~50% carbon  Bituminous 70–80% carbon  Anthracite >80% carbon  **Coal Formation**  Coal formed when tree ferns and mosses died and were subjected to continued pressure and heat underground.  **Composition of Coal**  **What is the chemical composition of coal?**  **Coal consists largely of condensed aromatic compounds of extremely high molar mass. These compounds have a high proportion of carbon compared with hydrogen.**  Coal is mined from both surface mines and underground mines. |  |