

the destruction of stratospheric (high-altitude) ozone, as discussed in the Chemical Connections feature “Chlorofluorocarbons and the Ozone Layer” on page 351.

## Physical Properties of Halogenated Alkanes

Halogenated alkane boiling points are generally higher than those of the corresponding alkane. An important factor contributing to this effect is the polarity of carbon–halogen bonds, which results in increased dipole–dipole interactions.

Some halogenated alkanes have densities that are greater than that of water, a situation not common for organic compounds. Chloroalkanes containing two or more chlorine atoms, bromoalkanes, and iodoalkanes are all more dense than water.

## CONCEPTS TO REMEMBER

**Carbon atom bonding characteristics.** Carbon atoms in organic compounds must have four bonds (Section 12.2).

**Types of hydrocarbons.** Hydrocarbons, binary compounds of carbon and hydrogen, are of two types: saturated and unsaturated. In saturated hydrocarbons, all carbon–carbon bonds are single bonds. Unsaturated hydrocarbons have one or more carbon–carbon multiple bonds—double bonds, triple bonds, or both (Section 12.3).

**Alkanes.** Alkanes are saturated hydrocarbons in which the carbon atom arrangement is that of an unbranched or branched chain. The formulas of all alkanes can be represented by the general formula  $C_nH_{2n+2}$ , where  $n$  is the number of carbon atoms present (Section 12.4).

**Structural formulas.** Structural formulas are two-dimensional representations of the arrangement of the atoms in molecules. These formulas give complete information about the arrangement of the atoms in a molecule but not the spatial orientation of the atoms. Two types of structural formulas are commonly encountered: expanded and condensed (Section 12.5).

**Isomers.** Isomers are compounds that have the same molecular formula, (that is, the same numbers and kinds of atoms) but that differ in the way the atoms are arranged (Section 12.6).

**Constitutional isomers.** Constitutional isomers are isomers that differ in the connectivity of atoms, that is, in the order in which atoms are attached to each other within molecules (Section 12.6).

**Conformations.** Conformations are differing orientations of the same molecule made possible by free rotation about single bonds in the molecule (Section 12.7).

**Alkane nomenclature.** The IUPAC name for an alkane is based on the longest continuous chain of carbon atoms in the molecule. A group of carbon atoms attached to the chain is an alkyl group. Both the position and the identity of the alkyl group are prefixed to the name of the longest carbon chain (Section 12.8).

**Line-angle structural formulas.** A line-angle structural formula is a structural representation in which a line represents a carbon–carbon bond and a carbon atom is understood to be present at every point where two lines meet and at the ends of the line. Line-angle structural

formulas are the most concise method for representing the structure of a hydrocarbon or hydrocarbon derivative (Section 12.9).

**Cycloalkanes.** Cycloalkanes are saturated hydrocarbons in which at least one cyclic arrangement of carbon atoms is present. The formulas of all cycloalkanes can be represented by the general formula  $C_nH_{2n}$ , where  $n$  is the number of carbon atoms present (Section 12.12).

**Cycloalkane nomenclature.** The IUPAC name for a cycloalkane is obtained by placing the prefix *cyclo-* before the alkane name that corresponds to the number of carbon atoms in the ring. Alkyl groups attached to the ring are located by using a ring-numbering system (Section 12.13).

**Cis-trans isomerism.** For certain disubstituted cycloalkanes, *cis-trans* isomers exist. *Cis-trans* isomers are compounds that have the same molecular and structural formulas but different arrangements of atoms in space because of restricted rotation about bonds (Section 12.14).

**Natural sources of saturated hydrocarbons.** Natural gas and petroleum are the largest and most important natural sources of both alkanes and cycloalkanes (Section 12.15).

**Physical properties of saturated hydrocarbons.** Saturated hydrocarbons are not soluble in water and have lower densities than water. Melting and boiling points increase with increasing carbon chain length or ring size (Section 12.16).

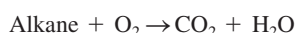
**Chemical properties of saturated hydrocarbons.** Two important reactions that saturated hydrocarbons undergo are combustion and halogenation. In combustion, saturated hydrocarbons burn in air to produce  $CO_2$  and  $H_2O$ . Halogenation is a substitution reaction in which one or more hydrogen atoms of the hydrocarbon are replaced by halogen atoms (Section 12.17).

**Halogenated alkanes.** Halogenated alkanes are hydrocarbon derivatives in which one or more halogen atoms have replaced hydrogen atoms of the alkane (Section 12.18).

**Halogenated alkane nomenclature.** Halogenated alkanes are named by using the rules that apply to branched-chain alkanes, with halogen substituents being treated the same as alkyl groups (Section 12.18).

## KEY REACTIONS AND EQUATIONS

1. Combustion (rapid reaction with  $O_2$ ) of alkanes (Section 12.17)



2. Halogenation of alkanes (Section 12.17)

