3.S: Functional Groups (Summary)

To ensure that you understand the material in this chapter, you should review the meanings of the following bold terms in the summary and ask yourself how they relate to the topics in the chapter.

A **functional group** is any atom or atom group that confers characteristic properties to a family of compounds.

The hydroxyl group (OH) is the functional group of the **alcohols**. The alcohols are represented by the general formula ROH. Alcohols are derived from alkanes by replacing one or more hydrogen atoms by an OH group. A **primary (1°) alcohol** (RCH_2OH) has the OH group on a carbon atom attached to one other carbon atom; a **secondary (2°) alcohol** (R_2CHOH) has the OH group on a carbon atom attached to two other carbon atoms; and a **tertiary (3°) alcohol** (R_3COH) has the OH group on a carbon atom attached to three other carbon atoms.

The ability to engage in hydrogen bonding greatly increases the boiling points of alcohols compared to hydrocarbons of comparable molar mass. Alcohols can also engage in hydrogen bonding with water molecules, and those with up to about four carbon atoms are soluble in water.

Rubbing alcohol is usually a 70% aqueous solution of isopropyl alcohol. Ethanol is also used in some rubbing alcohol formulations.

Alcohols can be named using the IUPAC or common systems. The IUPAC nomenclature of alcohols is determined as: location and identity of substituents + parent prefix (with location of functional group) + ol suffix. The common name of alcohols is identified as: identity of alkyl group + alcohol .

Phenols (ArOH) are compounds having the OH group attached to an aromatic ring. IUPAC nomenclature of phenols: location and identity of substituents + phenol

Ethers (R–O–R′, R–O–Ar, Ar–O–Ar) are compounds in which an oxygen atom is joined to two organic groups. Ether molecules have no OH group and thus no hydrogen bonding. Ethers therefore have quite low boiling points for a given molar mass. Ether molecules have an oxygen atom and can engage in hydrogen bonding with water molecules. An ether molecule has about the same solubility in water as the alcohol that is isomeric with it. To give ethers common names, simply name the groups attached to the oxygen atom, followed by the generic name *ether*. If both groups are the same, the group name should be preceded by the prefix *di-*.

A **thiol** is a compound with a sulhydryl (SH) functional group. **Thioethers** are sulfur analogs of ethers that have the form general formula R–S–R′. The name of thiols is determined by: location and identity of substituents + parent alkane + thiol suffix (with location of functional group).

Amines are derivatives of ammonia in which one, two, or all three hydrogen atoms are replaced by hydrocarbon groups. A **primary (1°) amine** (RNH_2) has one carbon atom attached to the nitrogen of the functional group; a **secondary (2°) amine** (R_2NH) has two carbon atoms attached to the nitrogen; and a **tertiary (3°) amine** (R_3N) has three carbon atoms attached to the nitrogen. Common names of amines indicate the alkyl groups attached to the nitrogen atom, followed by the suffix *-amine*.

The physical properties of the the amines may vary depending on the classification. Primary and secondary amines have higher boiling points than those of alkanes or ethers of similar molar mass because they can engage in hydrogen bonding. Their boiling points are lower than those of alcohols because alcohol molecules have hydrogen atoms bonded to an oxygen atom, which is more electronegative. The boiling points of tertiary amines, which cannot engage in hydrogen bonding because they have no hydrogen atom on the nitrogen atom, are comparable to those of alkanes and ethers of similar molar mass. Because all three classes of amines can engage in hydrogen bonding with water, amines of low molar mass are quite soluble in water.

Amines are weak bases, so they are able to accept protons from acids. When an amine reacts with water, a **protonated amine** is produced. If the amine reacts with a strong acid, a salt, often referred to as an **amine salt**, is produced.