Table R — Organic Functional Groups

Overview:

In Table Q you were introduced to homologous series of hydrocarbons. In this table other homologous series of organic compounds are shown. These organic compounds are formed when one or more hydrogen atoms of a hydrocarbon were replaced by other atoms or groups of atoms. These groups of atoms are called functional groups. A functional group is a particular arrangement of atoms, which gives characteristic properties to an organic molecule.

The Table:

The table shows the Class of Compound, Functional Group, General Formula and an Example of a compound containing that functional group. The *R* (in the General Formula) represents what is left of the hydrocarbon molecule after one or more of the hydrogen atoms of that molecule have been replaced by a different atom or group of atoms called the functional group. The name of the new compound is based on the nature of the functional group. The names of the compounds in each series are based on the name of the hydrocarbon containing the same number of carbon atoms as in the longest continuous chain of carbon atoms in the molecule that contains the functional group.

Class of Compound	Functional Group	General Formula	Example
halide (halocarbon)	—F (fluoro-) —Cl (chloro-) —Br (bromo-) —I (iodo-)	*R*—*X* (*X* represents any halogen)	$CH_3CHClCH_3$ 2-chloropropane
alcohol	—OH	*R*—OH	$CH_3CH_2CH_2OH$ 1-propanol
ether	—O—	*R*—O—*R′*	$CH_3OCH_2CH_3$ methyl ethyl ether
aldehyde	$-C(=O)-H$	$R-C(=O)-H$	$CH_3CH_2C(=O)-H$ propanal
ketone	$-C(=O)-$	$R-C(=O)-R'$	$CH_3CCH_2CH_2CH_3$ (=O) 2-pentanone
organic acid	$-C(=O)-OH$	$R-C(=O)-OH$	$CH_3CH_2C(=O)-OH$ propanoic acid
ester	$-C(=O)-O-$	$R-C(=O)-O-R'$	$CH_3CH_2C(=O)OCH_3$ methyl propanoate
amine	$-\overset{\vert}{N}-$	$R-\overset{R'}{\overset{\vert}{N}}-R''$	$CH_3CH_2CH_2NH_2$ 1-propanamine
amide	$-C(=O)-NH$	$R-C(=O)-\overset{R'}{N}H$	$CH_3CH_2C(=O)-NH_2$ propanamide

Note: *R* represents a bonded atom or group of atoms.

To better understand how this table works, the first two Classes of Compounds (halide and alcohol) will be explained in detail. (See next page.)

Halides:

The first row shows the class of compounds called the halides or halocarbons. A halide is produced when a Group 17 element (the halogens) replaces a hydrogen atom in a hydrocarbon molecule. These elements are shown as the functional group. The general formula for a halide is then R–X, where X represents any halogen. In the example shown, a chlorine atom has taken the place of one hydrogen atom from the hydrocarbon molecule. In naming the compound, the name of the halogen is modified to end in –o, hence chloro-. The rest of the name is derived from the name of the corresponding hydrocarbon with the same number of carbon atoms, in this case propane (3 carbon atoms, see Table P). The number 2 in the name represents the position of the chlorine atom in the chain of carbon atoms, in this case, the second from either end.

Alcohols:

The second row shows the class of compounds known as the alcohols. All alcohols must contain the –OH functional group. The general formula is then R–OH. The example shows this functional group (–OH) attached to the end of this molecule. The naming of the alcohols is done by replacing the final –e of the hydrocarbon name with –ol.

IUPAC Nomenclature:

As the table shows, each class of compounds has a different functional group. The name of the compound indicates the functional group present in the compound. The name of the parent hydrocarbon is usually modified by replacing the final –e of the name with a suffix indicating that class of compounds or functional group. *For example:* alcohols end in –ol, ketones end in –one, organic acids end in –oic, aldehydes end in –al, esters end in –ate, amines end in –ine

If necessary, the longest chain of carbon atoms is numbered to show the position of the functional group in that chain, using the smallest number.

Additional Information:

- The –OH of the alcohols does not ionize to produce the hydroxide ion (see Table E) that produces a basic solution.
- Esterification is the reaction between an acid and an alcohol to produce an ester and water. Organic esters are characterized by a pleasant taste and fragrance. They are used in artificial flavorings.
- Examples of organic compounds found in Table R:

  Ethyl alcohol (CH_3CH_2OH) is the alcohol found in alcoholic beverages and is the product of the fermentation reaction.

  2-propanol ($CH_3CHOHCH_3$) is rubbing alcohol.

  Diethyl ether ($C_2H_5OC_2H_5$) is operating room ether.

  Methanal (HCHO), an aldehyde, also called formaldehyde, is a liquid used to preserve animal specimens.

  Propanone (CH_3COCH_3), a ketone, also called acetone, is a common industrial solvent.

  Ethanoic acid (CH_3COOH), an organic acid, also called acetic acid, is in vinegar.

Set 1 — Organic Functional Groups

1. The functional group — COOH is found in

   (1) esters (3) alcohols
   (2) aldehydes (4) organic acids 1 _____

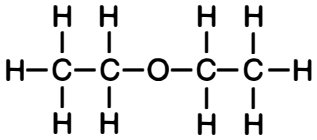
2. One molecule of propanol contains a total of

   (1) one –OH group
   (2) two $-CH_3$ groups
   (3) three –OH groups
   (4) three $-CH_3$ groups 2 _____

3. If a compound contains only one –OH functional group attached to the end carbon in the chain, it is classified as a

   (1) halide (3) ether
   (2) alcohol (4) ketone 3 _____

4. Given the structural formula:



   The compound represented by this formula can be classified as an

   (1) organic acid (3) ester
   (2) ether (4) aldehyde 4 _____

5. Ethanol and dimethyl ether have different chemical and physical properties because they have different

   (1) functional groups
   (2) molecular masses
   (3) numbers of covalent bonds
   (4) percent compositions by mass 5 _____

6. Which compound an ketone?

   (1) ethyne (3) propanone
   (2) methanal (4) chloropropane 6 _____

7. The organic compound represented by the condensed structural formula

   $CH_3CH_2CH_2CHO$

   is classified as an

   (1) alcohol (3) ester
   (2) aldehyde (4) ether 7 _____

8. What is the IUPAC name for the compound that has the condensed structural formula $CH_3CH_2CH_2CHO$?

   (1) butanal (3) propanal
   (2) butanol (4) propanol 8 _____

9. The compounds 2-butanol and 2-butene both contain

   (1) double bonds, only
   (2) single bonds, only
   (3) carbon atoms
   (4) oxygen atoms 9 _____

10. Which of these compounds has chemical properties most similar to the chemical properties of ethanoic acid?

    (1) C_3H_7COOH
    (2) C_2H_5OH
    (3) $C_2H_5COOC_2H_5$
    (4) $C_2H_5OC_2H_5$ 10 ____