# GLOSSARY OF CHEM 1110 ORGANIC CHEMISTRY TERMS

**acetic acid** ($CH_3CO_2H$): trivial name for ethanoic acid, formed by the oxidation of ethanal or ethanol with $KMnO_4$.

**acetone** ($CH_3COCH_3$ or $(CH_3)_2CO$): trivial name for propanone, formed by the oxidation of 2-propanol with $KMnO_4$.

**achiral molecule**: a molecule that does not contain a stereogenic carbon; an achiral molecule has a plane of symmetry and is superimposable on its mirror image.

**acid (carboxylic acid)** ($RCO_2H$): a compound containing the carboxyl group.

**acid anhydride** ($(RCO)_2O$): a reactive derivative of a carboxylic acid; in the CHEM 1110 aspirin lab, acetic anhydride is used to convert salicylic acid to aspirin.

**acid/base reaction**: a reaction in which an acidic H atom is transferred from one molecule to another.

**addition reaction**: a reaction where a reagent is added across a double or triple bond in an organic compound to produce the corresponding saturated compound.

**alcohol** (R-OH): a compound which has a hydroxyl group bonded to an R group, where R is a hydrocarbon.

**aldehyde** (RCHO): a compound that contains a carbonyl group (C=O) at the end of the carbon chain, or that has the CHO attached to a ring.

**aliphatic**: a compound which does not contain a benzene ring; pentane and cyclohexane are aliphatic compounds.

**alkali metal** (a metal in Group IA on the periodic table): active metals which may be used to react with an alcohol to produce the corresponding metal alkoxide and hydrogen gas.

**alkane**: a hydrocarbon which contains only carbon-carbon single bonds; also classified as a saturated hydrocarbon. Straight or branched-chain alkanes have the general formula $C_nH_{2n+2}$.

**alkene**: a hydrocarbon which contains at least one carbon-carbon double bond; also classified as an unsaturated hydrocarbon. Straight or branched-chain alkenes have the general formula $C_nH_{2n}$.

**alkoxide** ($RO^-$): an ion containing a negative charge on oxygen; formed by the reaction of an alcohol with an active metal.

**alkoxy group** (RO-): a substituent containing an alkyl group linked to an oxygen.

**alkyl benzene** ($C_6H_5$-R): a benzene ring that has one alkyl group attached; the alkyl group (except quaternary alkyl groups) is susceptible to oxidation with hot $KMnO_4$ to yield benzoic acid ($C_6H_5CO_2H$).

**alkyl group** (R-): a substituent formed by removing one hydrogen atom from an alkane.

**alkyl halide** (R-X): a compound which contains at least one halogen atom.

**alkyne**: a hydrocarbon which contains at least one carbon-carbon triple bond; also classified as an unsaturated hydrocarbon. Straight or branched-chain alkynes have the general formula $C_nH_{2n-2}$.

**amide** ($RCONR_2$): the least reactive derivative of a carboxylic acid; it contains a carbonyl group (C=O) that is singly bonded to a nitrogen atom; the condensation product of a carboxylic acid with ammonia or an amine.

**amine** ($RNR_2$): a hydrocarbon derivative of ammonia ($NH_3$); primary, secondary, and tertiary amines have, respectively, one, two and three of the $NH_3$ hydrogen atoms replaced by hydrocarbon groups.

**amino acid**: a compound with a carboxyl group and an amino group. In an alpha amino acid, the amino group is on the carbon atom adjacent to the carboxyl group.

**amino group**: the $-NH_2$ group.

**aniline** ($C_6H_5NH_2$): a primary (1°) amine in which the $NH_2$ group is bonded directly to a benzene ring.

**aromatic**: a compound which contains a benzene ring.

**aspirin**: trivial name for the compound acetylsalicylic acid; formed by treating salicylic acid with acetic anhydride.

**asymmetric carbon atom**: a carbon atom with four different substituents; a stereogenic carbon.

**benzaldehyde** ($C_6H_5CHO$): simplest **aromatic aldehyde**, formed by the controlled oxidation of benzyl alcohol; vigorous oxidation yields benzoic acid.

**benzen**e: an aromatic cyclic hydrocarbon of formula $C_6H_6$.

**benzoic acid** ($C_6H_5CO_2H$): simplest aromatic carboxylic acid, formed by the vigorous oxidation of alkyl benzene, benzyl alcohol, and benzaldehyde.

**carbonyl group** (R-**CO**-R): a carbon atom which is connected to an oxygen atom with a double bond; the functional groups of aldehydes, ketones, carboxylic acids, esters and amides all contain a carbonyl group.

**carboxy group** ($-CO_2H$ or -COOH): a carbonyl group to which a hydroxyl group is attached; carboxylic acids have this functional group.

**catalyst**: a substance which changes the rate of a chemical reaction but is unchanged at the end of the reaction; an example would be the Pt used in the hydrogenation of alkenes.

**chirality**: the ability of an object or a compound to exist in right and left-handed forms; a chiral compound will rotate the plane of plane-polarized light.

**cis**: a geometric form of a substituted alkene or a cyclic compound in which two substituents are on the same side of the carbon-carbon double bond or the ring.

**constitutional isomers:** see structural isomerism

**cyclic compound**: a molecule which has the two ends of the carbon chain connected together to form a ring.

**cyclo**: prefix used to indicate the presence of a ring.

**dehydration**: an elimination reaction in which an alcohol reacts with concentrated acid to yield an alkene plus water.

**diene**: a hydrocarbon with two double bonds.

**diol**: a compound with two alcohol groups.

**double bond**: a group in which two pairs of electrons are shared between two atoms (C=C,C=O, C=N); a double bond is made up of a sigma bond and a pi bond.

**enantiomers**: stereoisomers which are mirror images; they can be considered to be right and left-handed molecules as they are not superimposable on each other.

**ester** (R-$CO_2$-R): also called a carboxylic ester; a molecule which contains a carbonyl group (C=O) that is singly bonded to another oxygen atom which is bonded to another carbon atom (-O-R); produced by the condensation reaction between a carboxylic acid and an alcohol.

**ether** (C-O-C): a molecule which contains a carbon-oxygen-carbon linkage.

**ethoxide** ($CH_3CH_2O^-$): anion formed by treating ethanol with an alkali metal.

**ethoxy group** ($CH_3CH_2O$-): a two carbon alkoxy susbtituent.

**ethyl alcohol** ($CH_3CH_2OH$): trivial name for ethanol.

**ethyl group** ($CH_3CH_2$-): a two carbon alkyl substituent.

**formaldehyde** ($CH_2O$): trivial name for methanal.

**formic acid** ($HCO_2H$): trivial name for methanoic acid.

**functional group**: a specific collection of atoms that reacts in a characteristic way, used as a means of classifying organic compounds into families; each functional group in a compound behaves independently, thus the reactivity of even complex molecules can be predicted.

**functional isomers**: compounds which have the same molecular formula that possess different functional groups.

**geometric isomers**: stereoisomers which differ in the geometry around either a carbon-carbon double bond or ring.

**halo group** (X-): substituent which is one of the four halogens; fluoro (F), chloro (Cl), bromo (Br), or iodo (I).

**halogenation**: the addition of a halogen molecule (only $Cl_2$ or $Br_2$) to an alkene to produce an alkyl dihalide or alkyne to produce an alkyl tetrahalide.

**heteroatoms:** elements other than carbon and hydrogen that are commonly found in organic molecules, such as nitrogen, oxygen and the halogens.

**homologous series**: compounds which differ only by the number of $CH_2$ units present; $CH_3CH_2Cl$, $CH_3CH_2CH_2Cl$, and $CH_3CH_2CH_2CH_2Cl$, all belong to the same homologous series (1° alkyl chlorides).

**hydration**: the addition of a molecule of water to the carbon-carbon double bond of an alkene to form an alcohol; the reaction follows Markovnikov's rule and requires a mineral acid catalyst ($H^+$).

**hydrocarbons**: compounds which contain only carbon and hydrogen.

**hydrohalogenation**: the addition of a molecule of HCl or HBr to an alkene to form an alkyl halide, or to an alkyne to form a geminal alkyl dihalide, the addition follows Markovnikov's rule.

**hydrolysis**: a substitution reaction in which a molecule of water replaces a leaving group in a compound; examples would include the hydrolysis of ester or amides to the corresponding carboxylic acids.

**hydroxyl group** (-OH): the functional group present in an alcohol.

**index of hydrogen deficiency (IHD):** a basis for the comparison of the molecular formula of a given compound to that of an acyclic alkane which has the same number of carbon atoms (since the latter has the maximum number of hydrogens per carbon possible $C_nH_{2n+2}$); can be used to determine possible structural formulas from a molecular formula; if the IHD = 1, the given compound may contain either 1 double bond or 1 ring; if IHD =2, the compound may contain 2 double bonds, 2 rings, a ring and a double bond, or one triple bond; etc.

**isobutyl**: the $(CH_3)_2CH\text{-}CH_2\text{-}$ group, the trivial name for the 2-methylpropyl group.

**isopropyl**: the $(CH_3)_2CH\text{-}$ group, the trivial name for the 1-methylethyl group.

**isomers**: compounds which have the same molecular formulas but different structures; they may be sub-classified as functional, geometric, optical, positional, skeletal, stereo, or structural.

**IUPAC** (International Union of Pure and Applied Chemistry): the organization that establishes the system of nomenclature for organic and inorganic compounds using prefixes and suffixes, developed in the late 19th century.

**ketone** (RCOR)**:** a compound which contains a carbonyl group (C=O) attached to two carbon atoms.

**Markovnikov's rule**: organic reaction in which the major product is the one predicted to form by adding a hydrogen atom to the carbon atom of a double bond which contains the greater number of hydrogen atoms.

**meta**-(*m*-): prefix used to describe disubstituted benzenes in which the two groups are in positions 1 and 3.

**methoxy group** ($CH_3O\text{-}$): the simplest alkoxy substituent.

**methyl alcohol** ($CH_3OH$): trivial name for methanol.

**methyl group** ($CH_3$-): the simplest alkyl substituent.

**nomenclature**: a method of systematically naming organic compounds using prefixes and suffixes.

**olefin**: another name for an alkene.

**optical activity**: refers to the ability of a compound to interact with plane polarized light; such a compound is said to be optically active and it will not be superimposable on its mirror image.

**optical isomers**: this refers to compounds which will rotate the plane of polarized light by the same amount, but in opposite directions; also called enantiomers (i.e. non-superimposable mirror images).

**ortho-** (*o*-): prefix used to describe disubstituted benzenes in which the two groups are in positions 1 and 2.

**oxidation**: a reaction in which electrons are lost by a species or molecule e.g. $2Cl^- \rightarrow Cl_2$; also the gain of carbon-oxygen bonds, and/or loss of carbon-hydrogen bonds e.g. 1-butanol $\rightarrow$ butanal $\rightarrow$ butanoic acid.

**para-** (*p*-): prefix used to describe disubstituted benzenes in which the two groups are in positions 1 and 4.

**phenol**: a compound containing an OH group attached to an aromatic ring; an aromatic alcohol (e.g. $C_6H_5OH$).

**phenyl group** ($C_6H_5$- or Ph-): the group formed by removing one hydrogen atom from benzene.

**plane of symmetry**: an imaginary surface which divides an object (or molecule) into two equal halves which are mirror images of each other.

**polarimeter**: an instrument used to measure the optical activity of a compound.

**positional isomers**: compounds which differ only in the position of a functional group; 2-pentanol and 3-pentanol are positional isomers.

**primary (1°)**: general term used to describe a specific structural arrangement in which a carbon atom is attached to one other carbon atom.

> **primary alcohol** ($RCH_2OH$): alcohol in which the OH group is bonded to a carbon bonded to one alkyl group.
>
> **primary amine** ($RNH_2$): amine in which the N atom is bonded to one alkyl group.

**propoxy group** ($CH_3CH_2CH_2O$-): a straight chain three carbon alkoxy substituent.

**propyl group** ($CH_3CH_2CH_2$-): a straight chain three carbon alkyl substituent.

**qualitative analysis:** visual tests used in the laboratory to determine the presence or absence of a given functional group:

**Beilstein Test**: the appearance of a green flame when a sample of an organic compound is burned on a copper wire is indicative of the presence of an alkyl halide.

**Brady's Test**: the formation of a yellow or orange precipitate when an organic compound is treated with Brady's reagent is indicative of the presence of an aldehyde or a ketone.

**Bromine Test**: the formation of a colourless solution when an organic compound is treated with a solution of bromine (orange-brown) is indicative of the presence of an unsaturated hydrocarbon (alkene or alkyne).

**$KHCO_3$ Test**: the rapid formation of bubbles of $CO_2$ when an organic compound is treated with $KHCO_3(aq)$ is indicative of the presence of a carboxylic acid.

**$KMnO_4$ Test**: the formation of a brown precipitate when an organic compound is treated with a basic solution of potassium permanganate (purple solution) is indicative of the presence of a functional group which can be oxidized (an alkene, alkyne, aldehyde, primary or secondary alcohol).

**Lucas Test**: the rapid formation of a milky suspension when an organic compound is treated with the Lucas reagent is indicative of the presence of a tertiary alcohol; secondary alcohols react much slower, and primary alcohols hardly at all.

**Sodium Test**: the evolution of hydrogen gas when an organic compound is treated with sodium metal is indicative of the presence of an alcohol or a carboxylic acid.

**Tollens' Test**: the formation of a silver mirror when an organic compound is treated with Tollens' reagent is indicative of the presence of an aldehyde.

**quaternary (4°) carbon:** a carbon that is bonded to four carbon atoms.

**reduction**: a reaction in which a substance gains electrons, or loses O atoms, or gains H atoms; examples would be: $Cl_2 \rightarrow 2Cl^-$, and the conversion of 2-butanone to 2-butanol.

**road map**: a type of question in which the structures of the compounds must be deduced from the formulas of the compounds and the results of various reactions.

**saturated**: a compound which does not contain any double or triple bonds.

**secondary (2°)**: general term used to describe a specific structural arrangement in which a carbon atom that is attached to two other carbon atoms.

**secondary alcohol** ($R_2CH\text{-}OH$): alcohol in which the OH group is bonded to a carbon atom bonded to two alkyl groups.

**secondary amine** ($R_2NH$): amine in which the N atom is bonded to two alkyl groups.

**side chain**: a chain of atoms which is attached to a longer chain of atoms; examples of side chains would be methyl, ethyl, propyl groups (among others).

**skeletal isomers**: isomers which differ in the length of the carbon chain; examples are pentane and dimethylpropane.

**stereochemistry**: the branch of organic chemistry that deals with the three-dimensional structure of molecules.

**stereogenic carbon** (asymmetric carbon): a carbon atom which is bonded to four different groups or atoms; a chiral molecule must contain a stereogenic carbon, and therefore has no plane of symmetry and is not superimposable on its mirror image.

**stereoisomers**: isomers which have the same bonding connectivity but have a different three-dimensional structure; examples would be cis-2-butene and trans-2-butene (geometric isomers), and the left and right handed forms of 2-butanol (enantiomers).

**structural formula**: a convention used to represent the structures of organic molecules in which not all the valence electrons of the atoms are shown.

**structural isomerism**: relation between two compounds which have the same molecular formula, but different structures; they may be further classified as functional, positional, or skeletal isomers. This relation is also called constitutional isomerism.

**substituent**: an atom or group of atoms that is attached to a group of atoms; examples would be Cl- (chloro), $NO_2$- (nitro), $CH_3CH_2$- (ethyl), etc...

**substitution reaction**: process in which one group or atom in a molecule is replaced by another group or atom.

**tert (*t*-)**: prefix used to indicate that the carbon atom connected to the main chain of a molecule is itself bonded to three carbon atoms: $(CH_3)_3C$- is the *t*-butyl group. This prefix is not counted for alphabetization purposes.

**tert-butyl (*t*-butyl)**: trivial name for the 1,1-dimethylethyl group.

**tertiary (3°)**: general term used to describe a specific structural arrangement.

**tertiary alcohol** ($R_3C$-OH): an alcohol in which the OH group is bonded to a carbon atom bonded to three alkyl groups.

**tertiary amine** ($R_3N$): an amine in which the N atom is bonded to three carbon atoms.

**toluene** ($C_6H_5CH_3$): trivial name for methylbenzene

**trans**: geometric form of a substituted alkene or cyclic compound in which two substituents are on opposite side of the carbon-carbon double bond or the ring.

**triple bond**: a group in which three pairs of electrons are shared between two atoms; carbon-carbon (C≡C) and carbon-nitrogen (C≡N) triple bonds are very common in organic compounds; a triple bond is made up of a sigma bond and two pi bonds.

**trivial name**: common name which has been used for a long period of time for a simple compound, or a simple common name for a very complicated structure. The structural formula cannot be deduced from the name using a set of rules.

**unit of unsaturation**: also called the index of hydrogen deficiency (IHD).

**unsaturated**: refers to a compound which contains at least one double or triple bond; addition of excess hydrogen to such a molecule will produce a saturated compound.