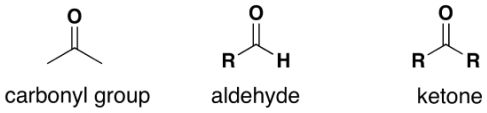
3.11: ALDEHYDES AND KETONES

learning objectives

- name aldehydes and ketones using IUPAC (systematic) and selected common name nomenclature
- draw the structure of aldehydes and ketones from IUPAC (systematic) and selected common names

Aldehydes and ketones contain the carbonyl group. Aldehydes derive their name from the *dehyd*ration of *al*cohols. Aldehydes contain the carbonyl group bonded to at least one hydrogen atom. Ketones contain the carbonyl group bonded to two carbon atoms.

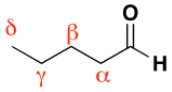
Aldehydes and ketones are organic compounds which incorporate a **carbonyl functional group**, C=O. The carbon atom of this group has two remaining bonds that may be occupied by hydrogen, alkyl or aryl substituents. If at least one of these substituents is hydrogen, the compound is an **aldehyde**. If neither is hydrogen, the compound is a **ketone**. When writing the condensed formulas for aldehydes and ketones, it is important to note that the carbonyl bond is not drawn. It must be recognized. The generic condensed formula for aldehydes is RCHO (CHO is our aldehyde CHUM) and RCOR' for ketones (no cute memorization aid - if you have one please share it.)



NAMING ALDEHYDES

The IUPAC system of nomenclature assigns a characteristic suffix ***-al*** to aldehydes. For example, $H_2C=O$ is methan**al**, more commonly called formaldehyde. Since an aldehyde carbonyl group must always lie at the end of a carbon chain, it is always is given the #1 location position in numbering and it is not necessary to include it in the name. There are several simple carbonyl containing compounds which have common names which are retained by IUPAC.

Also, there is a common method for naming aldehydes and ketones. For aldehydes common parent chain names, similar to those used for carboxylic acids, are used and the suffix ***–aldehyde*** is added to the end. In common names of aldehydes, carbon atoms near the carbonyl group are often designated by Greek letters. The atom adjacent to the carbonyl function is alpha, the next removed is beta and so on.



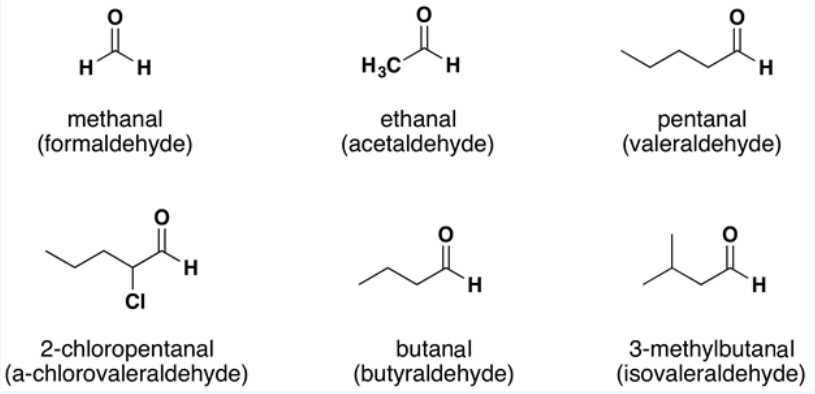
If the aldehyde moiety  (-CHO) is attached to a ring the suffix ***–carbaldehyde*** is added to the name of the ring. The carbon attached to this moiety will get the #1 location number in naming the ring.

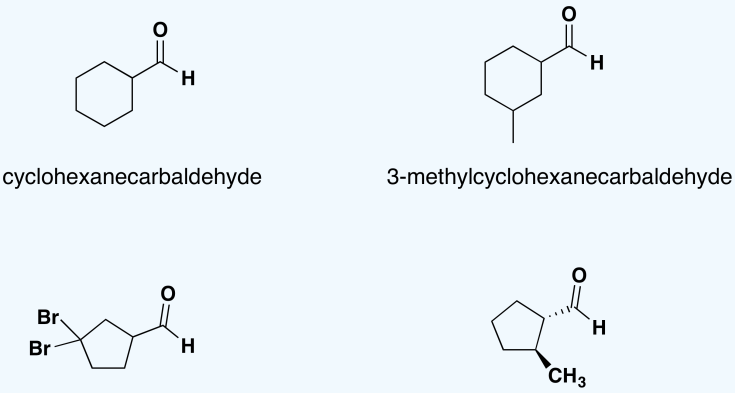
Summary of Aldehyde Nomenclature rules

1. Aldehydes take their name from their parent alkane chains. The ***-e*** is removed from the end and is replaced with ***-al***.
2. The aldehyde funtional group is given the #1 numbering location and this number is not included in the name.
3. For the common name of aldehydes start with the common parent chain name and add the suffix ***-aldehyde***. Substituent positions are shown with Greek letters.
4. When the -CHO functional group is attached to a ring the suffix ***-carbaldehyde*** is added, and the carbon attached to that group is C1.

Example 1

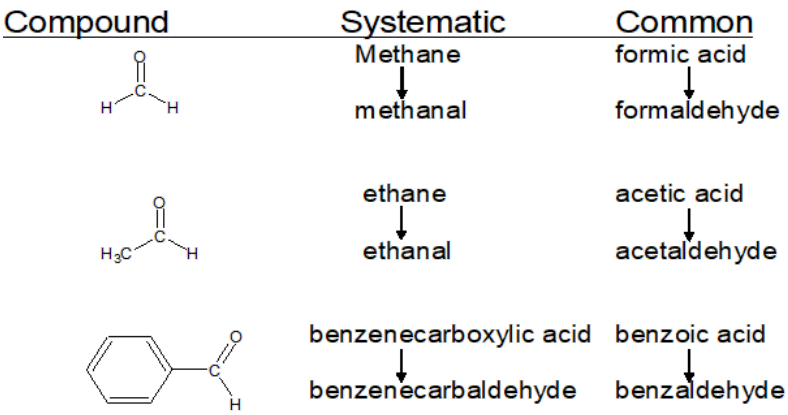
The IUPAC system names are given on top while the common name is given on the bottom in parentheses.





ALDEHYDE COMMON NAMES TO MEMORIZE

Aldehydes often called the formyl groups. There are some common names that are still used and need to be memorized. Recognizing the patterns can be helpful.



NOTE: When the aldehyde is the highest priority, there's no need to indicate its position. It has to be on carbon #1.

NAMING KETONES

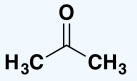
The IUPAC system of nomenclature assigns a characteristic suffix of **-one** to ketones. A ketone carbonyl function may be located anywhere within a chain or ring, and its position is usually given by a location number. Chain numbering normally starts from the end nearest the carbonyl group. Very simple ketones, such as propanone and phenylethanone do not require a locator number, since there is only one possible site for a ketone carbonyl function. The common names for ketones are formed by naming both alkyl groups attached to the carbonyl then adding the suffix **-ketone**. The attached alkyl groups are arranged in the name alphabetically.

Summary of Ketone Nomenclature rules

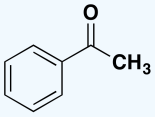
1. Ketones take their name from their parent alkane chains. The ending ***-e*** is removed and replaced with ***-one***.
2. The common name for ketones are simply the **substituent groups listed alphabetically + *ketone*.**
3. Some common ketones are known by their generic names. Such as the fact that *propanone* is commonly referred to as *acetone*.

Example 2

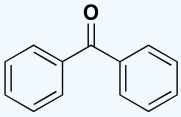
The IUPAC system names are given on top while the common name is given on the bottom in parentheses.



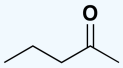
propanone
(acetone)



acetophenone
(methyl phenyl ketone)

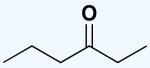


benzophenone
(diphenyl ketone)



2-pentanone
(methyl propyl ketone)

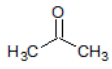
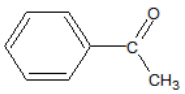
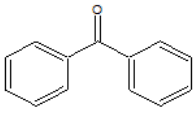
3-methyl-2-butanone
(methyl isopropyl ketone)



3-hexanone
(ethyl propyl ketone)

KETONE COMMON NAMES TO MEMORIZE

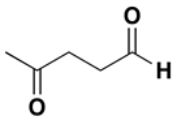
There are some common names that are still used and need to be memorized. Recognizing the patterns can be helpful.

Compound	Systematic	Common
	propane → propanone	acetone or dimethyl ketone
	1-phenylethane → 1-phenylethanone	acetophenone or methyl phenyl ketone
	benzophenone	diphenyl ketone

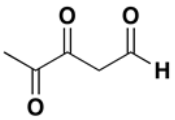
NAMING ALDEHYDES AND KETONES IN THE SAME MOLECULE

As with many molecules with two or more functional groups, one is given priority while the other is named as a substituent. Because aldehydes have a higher priority than ketones, molecules which contain both functional groups are named as aldehydes and the ketone is named as an **"oxo"** substituent. It is not necessary to give the aldehyde functional group a location number, however, it is usually necessary to give a location number to the ketone.

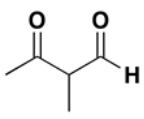
Example 3



4-oxopentanal



3,4-dioxopentanal

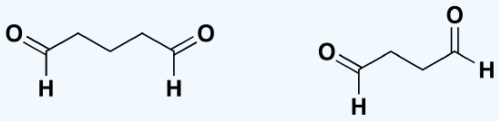


2-methyl-3-oxo-butanal

NAMING DIALDEHYDES AND DIKETONES

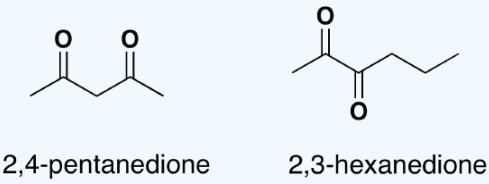
For dialdehydes the location numbers for both carbonyls are omitted because the aldehyde functional groups are expected to occupy the ends of the parent chain. The ending **–dial** is added to the end of the parent chain name.

Example 4



For diketones both carbonyls require a location number. The ending **-dione** or **-dial** is added to the end of the parent chain.

Example 5

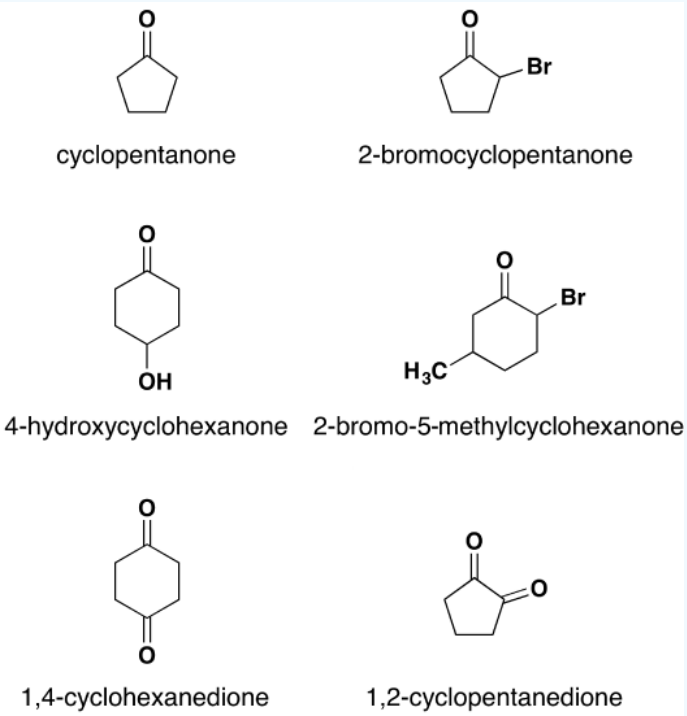


NAMING CYCLIC KETONES AND DIKETONES

In cyclic ketones the carbonyl group is assigned location position #1, and this number is not included in the name, unless more than one carbonyl group is present. The rest of the ring is numbered to give substituents the lowest possible location numbers. Remember the prefix **cyclo** is included before the parent chain name to indicate that it is in a ring. As with other ketones the **–e** ending is replaced with the **–one** to indicate the presence of a ketone.

With cycloalkanes which contain two ketones both carbonyls need to be given a location numbers. Also, an **–e** is not removed from the end, but the suffix **–dione** is added.

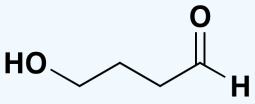
Example 6



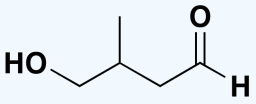
NAMING CARBONYLS AND HYDROXYLS IN THE SAME MOLECULE

When and aldehyde or ketone is present in a molecule which also contains an alcohol functional group the carbonyl is given nomenclature priority by the IUPAC system. This means that the carbonyl is given the lowest possible location number and the appropriate nomenclature suffix is included. In the case of alcohols the **OH** is named as a **hydroxyl** substituent. However, the **l** in hydroxyl is generally removed.

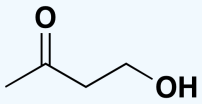
Example 7



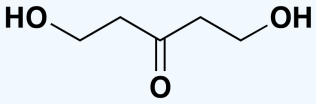
4-hydroxybutanal



4-hydroxy-3-methylbutanal



4-hydroxy-2-butanone



1,5-dihydroxy-3-pentanone

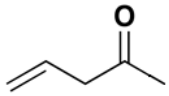
NAMING CARBONYLS AND ALKENES IN THE SAME MOLECULE

When and aldehyde or ketone is present in a molecule which also contains analkene functional group the carbonyl is given nomenclature priority by the IUPAC system. This means that the carbonyl is given the lowest possible location number and the appropriate nomenclature suffix is included. When carbonyls are included with an alkene the following order is followed:

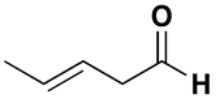
*(Location number of the alkene)-(Prefix name for the longest carbon chain minus the -**ane** ending)-(an -**en** ending to indicate the presence of an alkene)-(the location number of the carbonyl if a ketone is present)-(either an –**one** or and -**anal** ending).*

Remember that the carbonyl has priority so it should get the lowest possible location number. Also, remember that cis/tran or E/Z nomenclature for the alkene needs to be included if necessary.

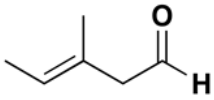
Example 8



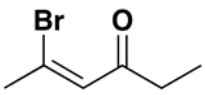
4-penten-2-one



trans-3-pentanal



(E)-3-methyl-3-pentenal

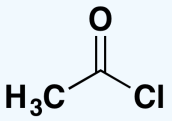


(Z)-5-bromo-4-hexen-3-one

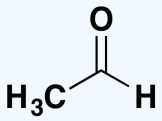
ALDEHYDES AND KETONES AS FRAGMENTS

- *Alkanoyl* is the common name of the alt fragment, though the older naming, *acyl*, is still widely used.
- *Formyl* is the common name of the alt fragment.
- *Acety* is the common name of the CH_3-C=O- fragment.

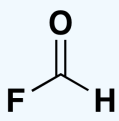
Example 9



acetyl chloride



acetylaldehyde

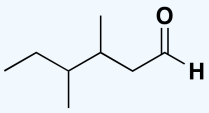


formyl fluoride

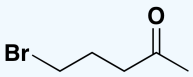
Exercise

1. Give the IUPAC name for each compound and write the condensed formulas for parts (a), (b), (c), (d), (e), (f), (h), (i), and (l).

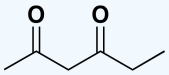
A)



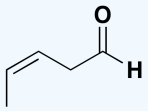
B)



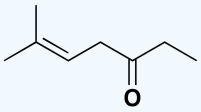
C)



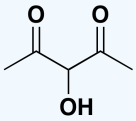
D)



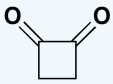
E)



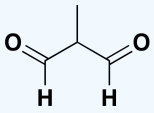
F)



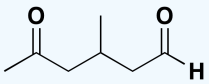
G)



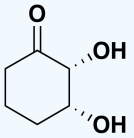
H)



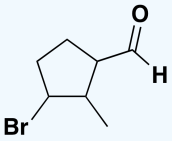
I)



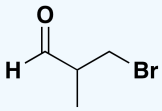
J)



K)



L)



2) Draw the bond-line structure and write the condensed formula {except for (b), (d) and (h)} corresponding to each name:

A) butanal

B) 2-hydroxycyclopentanone

C) 2,3-pentanedione

D) 1,3-cyclohexanedione

E) 4-hydoxy-3-methyl-2-butanone

F) (E) 3-methyl-2-hepten-4-one

G) 3-oxobutanal

H) *cis*-3-bromocyclohexanecarboaldehyde

I) butanedial

J) *trans*-2-methyl-3-hexenal

Answer

Solutions

1.

a) 3,4-dimethylhexanal; $CH_3CH_2CH(CH_3)CH(CH_3)CH_2CHO$

b) 5-bromo-2-pentanone; $CH_2BrCH_2CH_2COCH_3$

c) 2,4-hexanedione; $CH_3COCH_2COCH_2CH_3$

d) cis-3-Penenal; cis-CH_3CHHCH_2CHO

e) 6-methyl-5-hepten-3-one; $CH_3C(CH_3)CHCH_2COCH_2CH_3$ or $(CH_3)_2CCHCH_2COCH_2CH_3$

f) 3-hydroxy-2,4-pentanedione; $CH_3OCH(OH)COCH_3$

g) 1,2-cyclobutanedione

h) 2-methyl-propanedial; $CHOCH(CH_3)CHO$

i) 3-methyl-5-oxo-hexanal; $CH_3OCH_2CH(CH_3)CH_2CHO$

j) cis-2,3-dihydroxycyclohexanone

k) 3-Bromo-2-methylcyclopentanecarboaldehyde

l) 3-bromo-2-methylpropanal; $CHOCH(CH_3)CH_2Br$

2. condensed formulas below and bond-line structures to the right

a) $CH_3CH_2CH_2CHO$

c) $CH_3COCOCH_2CH_3$

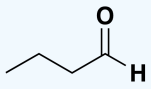
e) $CH_2(OH)CH(CH_3)COCH_3$

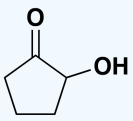
f) $CH_3CHC(CH_3)COCH_2CH_2CH_3$

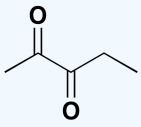
g) CH_3COCH_2CHO

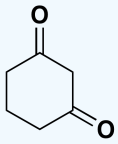
i) $CHOCH_2CH_2CHO$

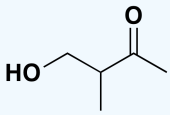
j) $CH_3CH_2CHCHCH(CH_3)CHO$

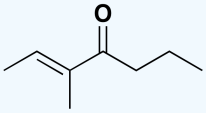
A) 

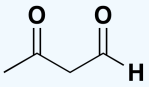
B) 

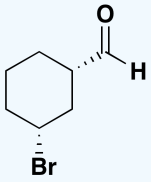
C) 

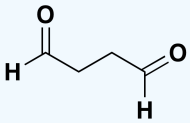
D) 

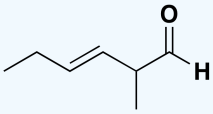
E) 

F) 

G) 

H) 

I) 

J) 

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2. Zumdahl, Steven S., and Susan A. Zumdahl. Chemistry. 6th ed. Boston: Houghton Mifflin College Division, 2002.

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