Classifying Hydrocarbons

- alkanes- single C-C bonds, if all C's have H's attached, molecules are called _____ hydrocarbons
- alkenes- have one or more C=C _____ bonds
- alkynes- have one or more C≡C _____ bonds
- alkenes & alkynes are called unsaturated hydrocarbons because they have _____ than the maximum possible number of H atoms
- can form either a straight chain or a _____ (ring) structure
- hydrocarbons which are attached to the main structure are called _____ groups and are named according to the number of carbons

Table 2 Alkanes and Related Alkyl Groups

Prefix	IUPAC name	Formula	Alkyl group	Alkyl formula
meth-	methane	$CH_{4(g)}$	methyl-	$-CH_3$
eth-	ethane	$C_2H_{6(g)}$	ethyl-	$-C_2H_5$
prop-	propane	$C_3H_{8(g)}$	propyl-	$-C_3H_7$
but-	butane	$C_4H_{10(g)}$	butyl-	$-C_4H_9$
pent-	pentane	$C_5H_{12(l)}$	pentyl-	$-C_5H_{11}$
hex-	hexane	$C_6H_{14(l)}$	hexyl-	$-C_6H_{13}$
hept-	heptane	$C_7H_{16(l)}$	heptyl-	$-C_7H_{15}$
oct-	octane	$C_8H_{18(l)}$	octyl-	$-C_8H_{17}$
non-	nonane	$C_9H_{20(l)}$	nonyl-	$-C_9H_{19}$
dec-	decane	$C_{10}H_{22(l)}$	decyl-	$-C_{10}H_{21}$

- a 4th group are the _____ hydrocarbons which have a unique ring structure
- simplest is _____ and all others are derivatives of benzene

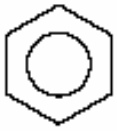


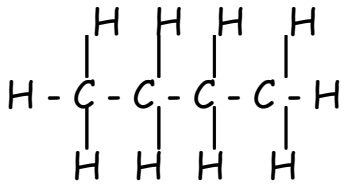
Figure 2
Benzene, C_6H_6, is colourless, flammable, toxic, and carcinogenic, and has a pleasant odour. Its melting point is 5.5°C and its boiling point 80.1°C. It is widely used in the manufacture of plastics, dyes, synthetic rubber, and drugs.

Drawing Hydrocarbons

Four types of diagrams can be used to represent the structure of a hydrocarbon: e.g. butane

1)

Shows all the atoms in a structure and the way they are bonded together.



2)

Shows the bonds between carbon atoms, not the bonds between carbon and hydrogen atoms.

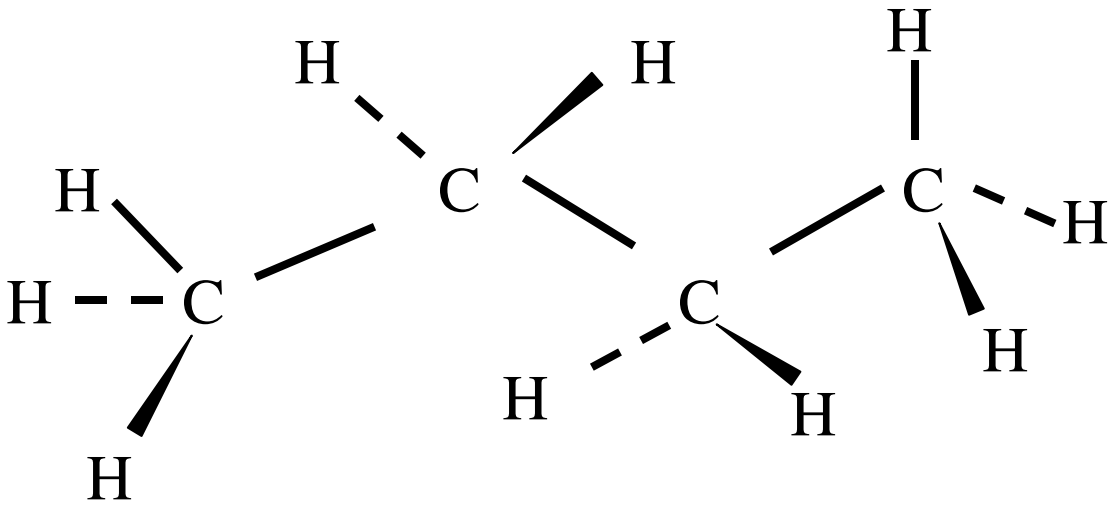
$$CH_3 - CH_2 - CH_2 - CH_3$$

3)

The end of each line, and the points at which the lines meet represent carbon atoms.

4)

Wedges are used to give the impression that an atom or group is coming out of the page. Dashed lines indicate an atom being pushed into the page.



SUMMARY Naming Branched Alkanes

Step 1 Identify the longest carbon chain; note that structural diagrams can be deceiving—the longest chain may travel through one or more "branches" in the diagram.

Step 2 Number the carbon atoms, starting with the end that is closest to the branch(es).

Step 3 Name each branch and identify its location on the parent chain by the number of the carbon at the point of attachment. Note that the name with the lowest numerals for the branches is preferred. (This may require restarting your count from the other end of the longest chain.)

Step 4 Write the complete IUPAC name, following this format: (number of location)-(branch name)(parent chain).

Step 5 When more than one branch is present, the branches are listed either in alphabetical order or in order of complexity; in this book, we will follow the alphabetical order.

Note: When naming cyclic hydrocarbons, the carbon atoms that form the ring structure form the parent chain; the prefix *cyclo-* is added to the parent hydrocarbon name, and the naming of substituted groups is the same as for noncyclic compounds.

Note: When naming propyl & butyl groups we have to consider how these groups attach onto the parent chain
i.e. when an alkyl group has 3 or more C atoms the group can attach either at an end C atom or at a middle C atom (see Fig.4 & 5)

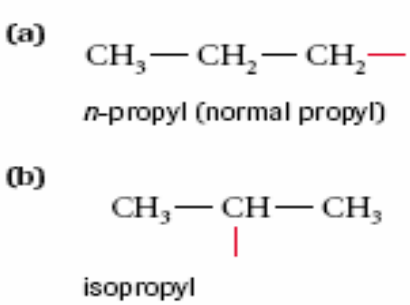


Figure 4
Two isomers of the propyl group. The coloured bond indicates where the group is attached to the larger molecule.

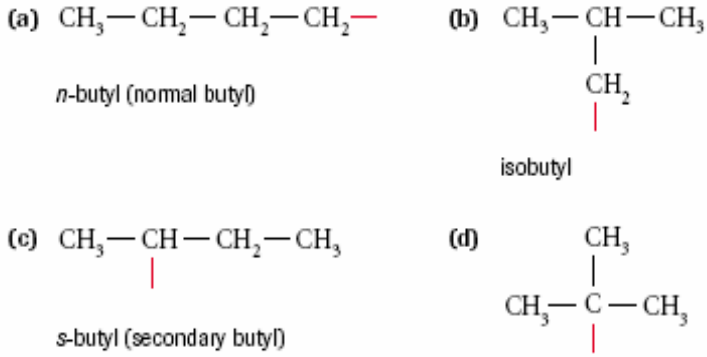


Figure 5
Four isomers of the butyl group

Classes of Hydrocarbons

Alkanes

Aliphatic hydrocarbons with molecules containing only carbon to carbon single bonds (_____) with an open (non-cyclic) structure. The simplest alkane is _____ $CH_4(g)$

All have the general formula _____ (n= C atoms)

The hydrocarbons are named according to the number of carbon atoms in the chain, and the presence of side chains.

1. Draw condensed structural formulas for the following:

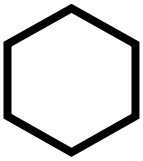
a) 2-methyl pentane b) 2,3-dimethylbutane

2. Draw the following and correct the following names:

a) 3-methylbutane b) 2,3,3-trimethylbutane

Physical Properties	Chemical Properties
• Relatively low mp and bp that ↑ as length of molecule ↑ . • _____ chains have a ↓ bp than a straight chain of same length. •Molecules are non-polar and attracted by dispersion forces • Insoluble in water (non-polar).	• Relatively low reactivity but will undergo: i) combustion reactions. ii) substitution reactions. (e.g. sub. H for a halogen) iii) cracking reactions which produce smaller chained alkanes.

_____ are isomers of _____ (C_nH_{2n}) . They occur when two ends of a hydrocarbon chain are joined together with the removal of two H atoms.

e.g. cyclohexane 

Draw condensed structural formulas for the following:

a) methylcyclobutane

b) 1,2,3-trimethyl cyclopropane

Alkenes (unsaturated hydrocarbons)

Aliphatic hydrocarbons with molecules containing at least 1 carbon to carbon _____ bond with an open (non-cyclic) structure.

The simplest alkene is _____ $C_2H_4(g)$

SUMMARY **Naming Alkenes and Alkynes**

Step 1. The parent chain must be an alkene or alkyne, and thus must contain the multiple bond.

Step 2. When numbering the C atoms in the parent chain, begin with the end closest to the multiple bond.

Step 3. The location of the multiple bond is indicated by the number of the C atom that begins the multiple bond; for example, if a double bond is between the second and third C atoms of a pentene, it is named 2-pentene.

Step 4. The presence and location of multiple double bonds or triple bonds is indicated by the prefixes *di-*, *tri-*, etc.; for example, an octene with double bonds at the second, fourth, and sixth C atoms is named 2,4,6-octatriene.

All have the general formula C_nH_{2n} (n = C atoms)

1. Draw expanded structural formulas for the following:

a) 3-methyl-1-pentene b) 2-methyl-1,3-pentadiene

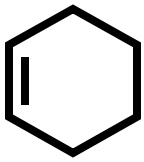
2. Draw the following as expanded formulas and correct the following names:

a) 2,4-pentadiene b) 3-chloro-1,3-butadiene

Physical Properties	Chemical Properties
• Bp usually less than a similar sized alkane • Insoluble in water (non-polar).	• Reactive, undergoing the following reactions: i) combustion . ii) addition (e.g. add a halogen or H atom. iii) polymerization. • Can be prepared by dehydration from an alcohol.

_____ are isomers of _____ (C_nH_{2n-2})

e.g. Cyclohexene



Draw condensed structural formulas for the following:

a) 1,2,3-trimethyl cyclopropene

b) 1,1-dicyclopropyl-2-methyl-1-propene

<u>Alkynes</u> (_____ hydrocarbons)

Aliphatic hydrocarbons with molecules containing at least 1 carbon to carbon _____ bond with an open (non-cyclic) structure.

The simplest alkyne is _____ $C_2H_2(g)$

All have the general formula _____ (n = C atoms)

Alkynes have chemical and physical properties very similar to _____.

1. Draw expanded structural formulas for the following:

a) 3-methyl-1-pentyne b) 4,4,5-trimethyl-2-hexyne

2. Draw the following and correct the following names:

a) 3,3-dimethyl-1-propyn b) 2,2-diethyl-4-nonyne

Isomers

There are two main types of isomers:

i) _____ Isomers

Structural isomers are chemicals with the same molecular formula but different _____ _____ and different names e.g.

a) butane b) 2-methylpropane

ii) _____ Isomers

Geometric isomers differ in structure only by the position of groups attached on either side of a carbon carbon _____ bond e.g.

a) cis-2-butene b) trans-2-butene

both groups are on the SAME side of the structure

both groups are on the OPPOSITE side of molecular the molecular structure

Chemical Reactions of Hydrocarbons

1) Chemical Reactions of Alkanes

- alkanes because of their C-C bonds are relatively _____ due to their being _____ to break
- they do participate in _____ reactions, making them useful as fuels

i)

large alkane + hydrogen gas → smaller alkane

ii)

small alkane → larger alkane (or more branched) + hydrogen gas

iii)

$2C_6H_{10}(g) + 13\ O_2(g)\ \ 8CO_2\ (g) + 10\ H_2O(g)$ + energy

iv)

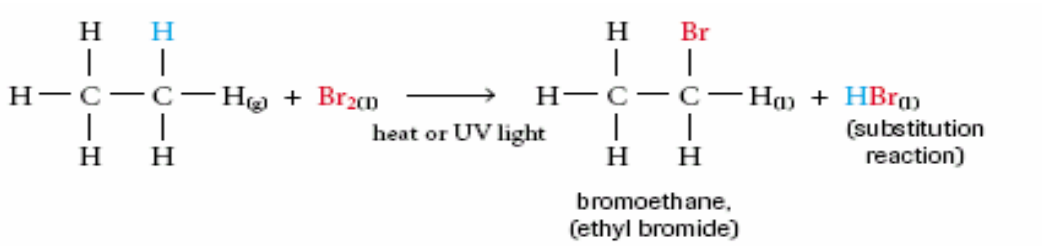
produces carbon and carbon monoxide

alkane + $O_2(g) \rightarrow CO_{2(g)} + H_2O_{(l)} + CO_{(g)} + C_{(g)}$ + energy

v)

Alkane + halogen → hydrogen halide + alkylhalide

e.g. $C_2H_6(g) + Br_2(g) \rightarrow HBr(g) + C_2H_5Br(l)$

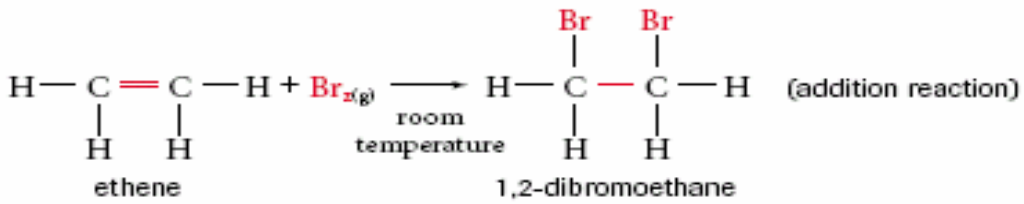


Adding more Br_2 can lead to substitution of another H atom.

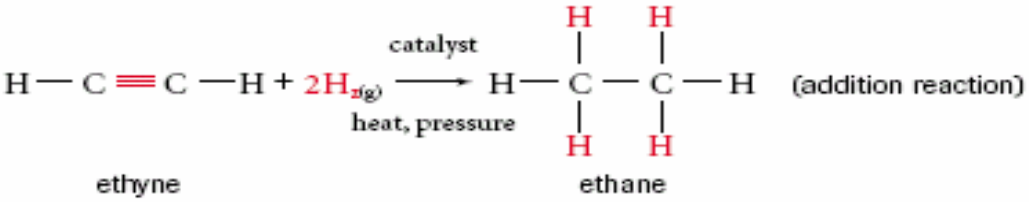
2) Chemical Reactions of Alkenes/Alkynes

- both exhibit _____ reactivity than alkanes i.e. if reacted with Br_2 the reaction will be fast and will occur at room temperature
- both undergo a characteristic reaction called an _____ *reaction*, where atoms are _____ to the molecule with no loss of H atoms
- addition reactions can involve halogens, H, hydrogen halides,and water, given the right conditions.

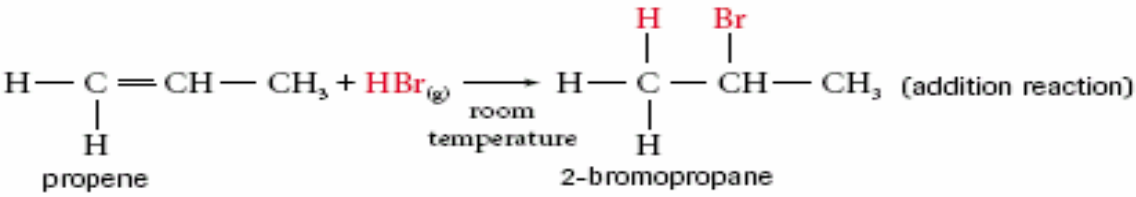
Halogenation (with Br_2 or Cl_2)



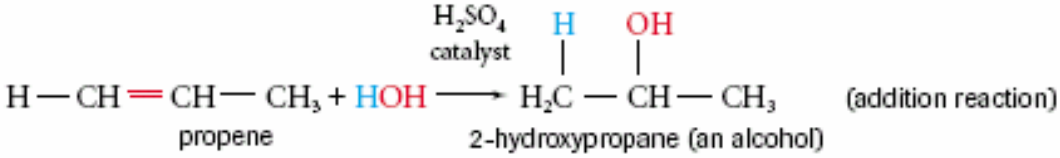
Hydrogenation (with H_2)



Hydrohalogenation (with hydrogen halides)



Hydration (with H_2O)



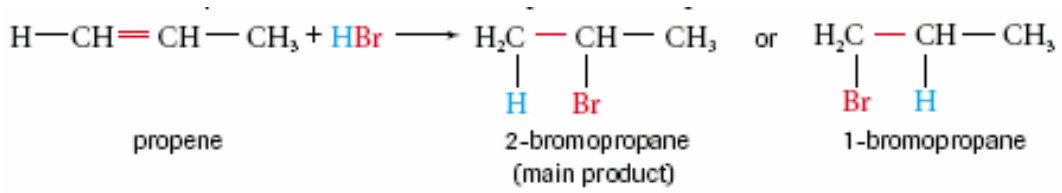
➢common prefixes for functional groups include;

Table 2 Prefixes for Functional Groups

Functional group	Prefix
–F	fluoro
–Cl	chloro
–Br	bromo
–I	iodo
–OH	hydroxy
$-NO_2$	nitro
$-NH_2$	amino

➢when molecules consisting of 2 identical atoms (H_2) are added to a double bond _____ __ possible product is formed, i.e a H atom gets added to each side of the double bond

➢but when molecules of a _____ atom is added, 2 different products may form e.g.



➢experiments have shown that only one main product is formed which leads us to Markovnikov's Rule…."the rich get richer"

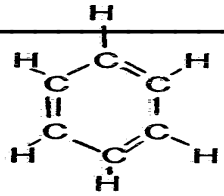
Markovnikov's Rule

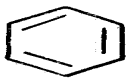
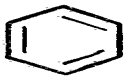
When a hydrogen halide orwater is added to an alkene or alkyne, the hydrogen atom bonds to the carbon atom within the double bond that *already has more hydrogen atoms*. This rule may be remembered simply as "the rich get richer."

1. Draw the major product for the reaction between 1-butene and hydrochloric acid

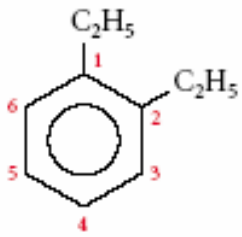
Aromatic Hydrocarbons

Benzene is a __ __ ring in which _____ carbon bonds _____ or move back and forth between adjacent carbons (_____).

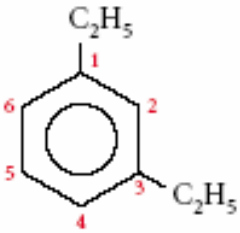


=  or  but  is preferred.

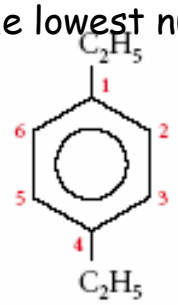
- benzene ring usually considered to be the parent chain and attached alkyl groups are the branches
- if a methyl group is attached, the molecule is called methylbenzene and we don't need to assign a number
- when we have 2 or more alkyl groups attached we need to use numbers (again numbering so that we have the lowest numbers)



(a) 1,2-diethylbenzene



(b) 1,3-diethylbenzene



(c) 1,4-diethylbenzene

Note: a) also known as _____- or o-diethylbenzene
b) also known as _____- or m-diethylenebenzene
c) also known as _____- or p-diethylenebenzene

- when an aromatic molecule is too difficult to name sometimes we would consider the benzene ring as the attached branch and not the parent molecule
- when the benzene ring is the attached branch it is called a _____ group e.g. 2-phenylbutane or s-butylbenzene

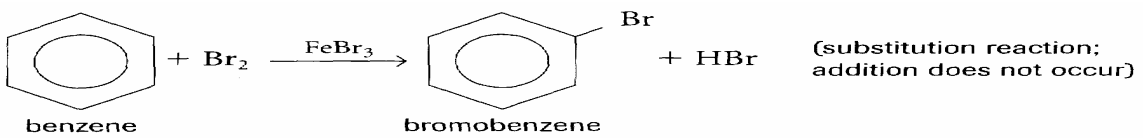
SUMMARY ***Naming Aromatic Hydrocarbons***

1. If an alkyl group is attached to a benzene ring, the compound is named as an alkylbenzene. Alternatively, the benzene ring may be considered as a branch of a large molecule; in this case, the benzene ring is called a phenyl group.
2. If more than one alkyl group is attached to a benzene ring, the groups are numbered using the lowest numbers possible, starting with one of the added groups.

Chemical Reactions of Aromatics

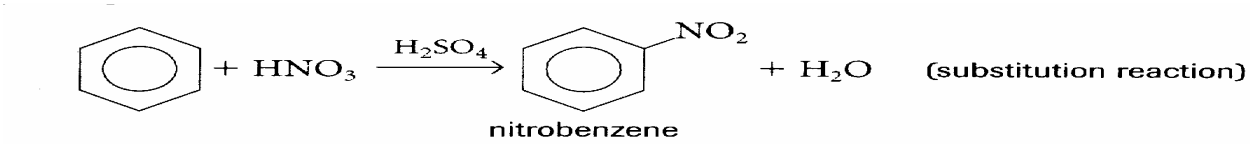
- although aromatic hydrocarbons are unsaturated, they do ___ undergo addition reactions except under _____ conditions
- they do undergo _____ reactions and in fact the H atoms are more easily replaced than in alkanes
- the reactivity of aromatic hydrocarbons are in between the alkanes & alkenes
- Examples:

i) Substitution Halogenation e.g. benzene + halogen (X_2)

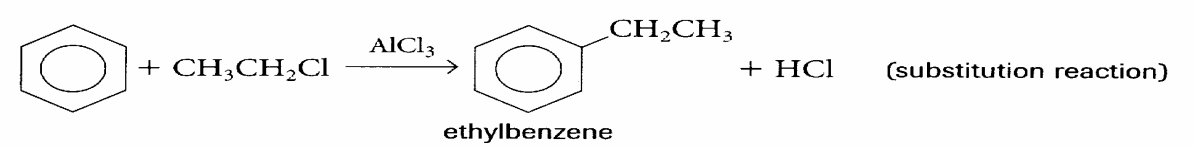


- in reaction (i) further reaction of bromobenzene with Br_2 results in substitution of another Br_2, resulting in 3 possible isomers of dibromobenzene

ii) Substitution Nitration e.g. benzene + nitric acid (HNO_3)

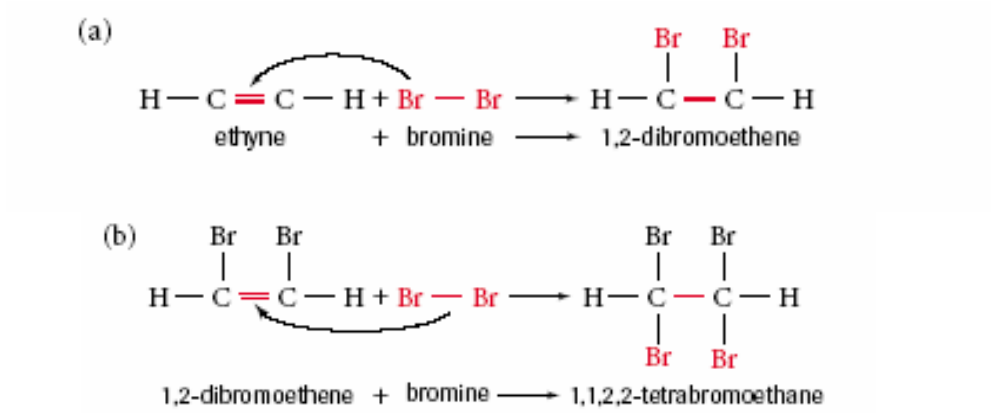


iii) Substitution Alkylation e.g. benzene + alkyl halide

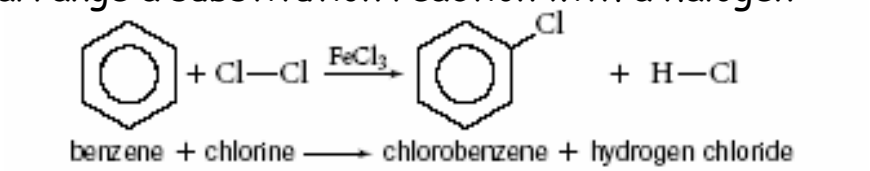


Preparing Organic Halides

➢can be produced by _____ reactions

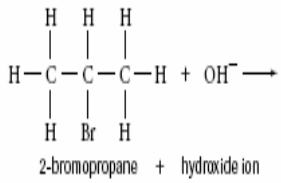


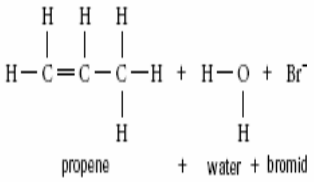
➢similarly, if we wanted to produce a halide of a benzene ring, we would arrange a substitution reaction with a halogen



Preparing Alkenes from Alkyl Halides: Elimination Reactions

➢alkyl halides can eliminate a H atom and a halogen atom from adjacent C atoms resulting in the formation of a double bond and therefore an alkane in an _____ reaction





SUMMARY *Organic Halides*

Functional group: R–X

Preparation:

- alkenes and alkynes → organic halides
  addition reactions with halogens or hydrogen halides
- alkanes and aromatics → organic halides
  substitution reactions with halogens or hydrogen halides

Pathway to other groups:

- alkyl halides → alkenes
  elimination reactions, removing hydrogen and halide ions

SUMMARY Reactions of Hydrocarbons

- All hydrocarbons undergo combustion reactions with oxygen to produce carbon dioxide and water.

Alkanes

- Primarily undergo **substitution** reactions, with heat or UV light:
  with halogens or hydrogen halides: halogenation
  with nitric acid

Alkenes and Alkynes

- Primarily undergo **addition** reactions:
  with H_2: hydrogenation
  with halogens or hydrogen halides: halogenation
  with water: hydration

Aromatics

- Primarily undergo **substitution** reactions:
  with X_2: halogenation, $Ø-X$
  with HNO_3: nitration, $Ø-NO_2$
  with RX: alkylation, $Ø-R$
- Do *not* undergo addition reactions.

Functional Groups

➢are used to identify compounds but also to explain properties like solubility, melting & boiling points, etc.

➢there are many different functional groups but they contain one of 3 main components

i.e.

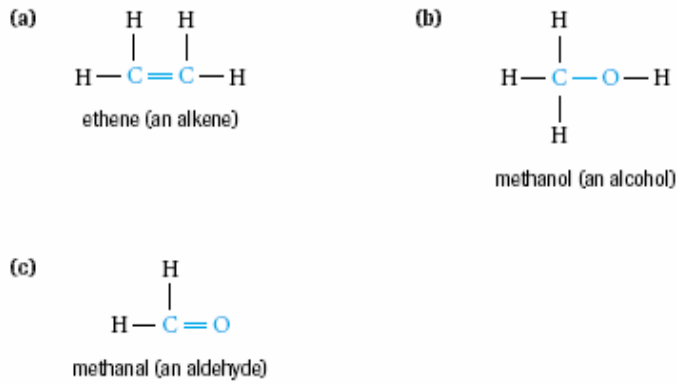


Figure 2
Examples of the three main components of functional groups:
(a) A double bond between two carbon atoms
(b) A single bond between carbon and a more electronegative atom (e.g., oxygen)
(c) A double bond between carbon and oxygen

Carbon-Carbon Bonds

➢C-C single bonds are strong covalent bonds and are _____ very reactive

➢C=C and CΞC are more reactive and their 2nd and 3rd bonds are more _____ broken

➢this allows these parts of a compound to be the _____ where reactions occur

Single Bonds Between C & more Electronegative Bonds

➢where there is an unequal attraction of the electrons the bond is _____ e.g. between C and a more electronegative atom

➢the C atom becomes more _____ and the O,N or halogen atom is more _____

➢an increase in _____ increases intermolecular _____ which in turn increases the melting & boiling points

➢O-H and N-H bonds form bonds with special properties and they can form _____ with other OH groups, they increase intermolecular attractions but also enables these molecules to _____ in polar solutes & solvents

➢"like dissolves like"

Double Bonded Carbon & Oxygen

➢this double covalent bond has 4 electrons being shared with ALL 4 electrons being more strongly attracted to the O atom

➢this bond is _____ polar with an accompanying increase in melting & boiling points and increased solubility in polar solvents

SUMMARY ***Three Main Components of Functional Groups***

Multiple bonds between C atoms

−C=C− −C≡C−	Unlike single C−C bonds, double and triple bonds allow atoms to be added to the chain.

C atom bonded to a more electronegative atom (O, N, halogen)

C−O C−N C−Cl, C−Br, C−F	Unequal sharing of electrons results in polar bonds, increasing intermolecular attraction, and raising boiling and melting points.
C−OH or C−NH−	These groups enable hydrogen bonding, increasing solubility in polar substances.

C atom double-bonded to an O atom

C=O	The resulting polar bond increases boiling point and melting point.

Alcohols R-OH

Consists of a "hydroxyl group" (OH) attached to a carbon atom.

The rules:

i) Name the longest carbon chain using the appropriate prefix (meth, eth, but, etc.)

ii) Add the suffix "___" to the end of the name. Use diol, triol etc. if the chain has more than one hydroxyl groups.

iii) The OH group takes priority over alkyl side chains and double or triple bonds when numbering

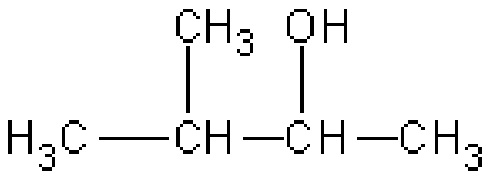
1. Draw the following:

a) 3-methyl-1-butanol

b) 1,2-propanediol

2. Name the following:

a)



b)

Classification of Alcohols

a) _____ Alcohols

The carbon to which the -OH is attached is in turn attached directly to one other carbon atom. e.g. ethanol

b) _____ Alcohols

The carbon to which the -OH is attached is in turn attached directly to 2 other carbon atoms. e.g. 2-propanol

c) _____ Alcohols

The carbon to which the -OH is attached is in turn attached directly to 3 other carbon atoms.

e.g. 2-methyl-2-propanol

d) _____ Alcohols

i) dihydroxy-contain 2 hydroxyl groups in the same molecule on different carbons.

e.g. 1,2-ethanediol

ii) trihydroxy-contain 3 hydroxyl groups in the same molecule on different carbon atoms.

e.g. 1,2,3-propanetriol

Chemical Reactions of Alcohols

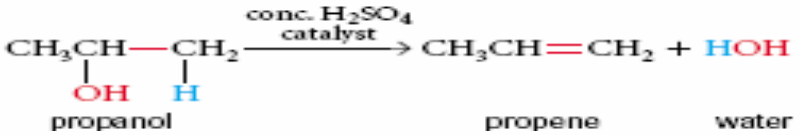
i) **Combustion of alcohols** *e.g.* alcohol + oxygen

$$2\,C_3H_7OH_{(l)} + 9\,O_{2(g)} \rightarrow 8\,H_2O_{(g)} + 6\,CO_{2(g)}$$

propanol oxygen water carbon dioxide

ii) **Substitution Hydrohalogenation** *e.g.* alcohol + halogen acid (HX)

iii) **Elimination** *e.g.* alcohol (in the presence of H_2SO_4)

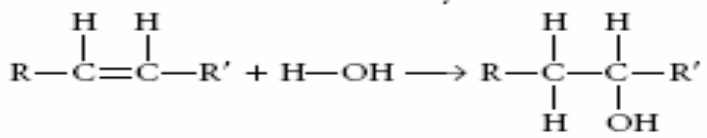


SUMMARY ***Alcohols***

Functional group: –OH, hydroxyl group

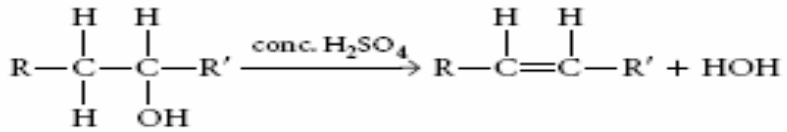
Preparation:

- alkenes → alcohols
  addition reaction with water: hydration



Pathways to other groups:

- alcohols → alkenes
  elimination reaction: dehydration



- alcohols → aldehydes → carboxylic acids (see Sections 1.6, 1.7)
  controlled oxidation reaction

Ether Linkage R-O-R

Contains a _____ atom in between carbon atoms.
Can be formed from the reaction between two hydroxyl groups. The rules:

Common Name

i) Groups attached to oxygen are named in alphabetical order.
ii) Add the suffix "_____".

IUPAC Name

i) Name according to longest alkyl group
ii) Treat the second alkyl group as an "_____" group and give it a position #.

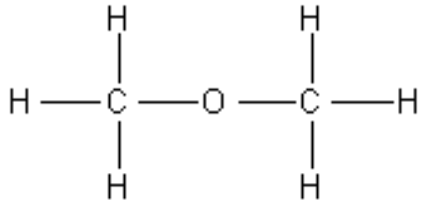
1. Draw the following:

a) ethoxyethane
(diethyl ether)

b) 1-ethoxy propane
(ethyl-propyl ether)

2. Name the following:

a)



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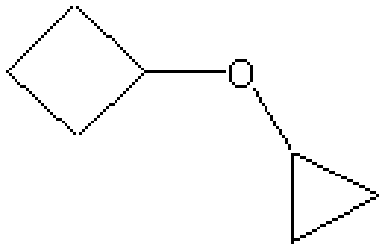


Properties of Ethers

- structure similar to _____ H-O-H and _____ R-O-H only in ethers, structure is _____ (where R=alkyl groups)
- alkyl groups may be identical or different
- there are ___ ____ bonds in ethers so they do not form hydrogen bonds
- C-O bonds are ____ and the _____ of the C-O-C group make ether molecules _____ polar than hydrocarbons
- intermolecular attractions between ether molecules are _____than hydrocarbons but weaker than those in alcohols, which is seen in Table 2 by looking at the boiling points

Table 2 Boiling Points of Analogous Compounds

Compound	Structure	Boiling point (°C)
ethane	$CH_3—CH_3$	−89
methoxymethane (dimethyl ether)	$CH_3—O—CH_3$	−23
ethanol	$CH_3—CH_2—O—H$	78.5
water	$H—O—H$	100

- ethers are good _____ for organic reactions because they mix readily with both polar and non-polar substances
- C-O bonds are _____ so ethers can dissolve polar substances while their alkyl groups allow them to dissolve non-polar substances
- C-O bonds are _____to break, making ethers _____ another property of a good solvent

Aldehydes R-CHO

Consist of a "_____ group" attached to a hydrogen at the end of a hydrocarbon chain. The rules:

i) Name the longest carbon chain using the appropriate prefix and add the suffix "____" to the end of the name.
ii) Always give the carbon atom of the carbonyl group position #1.

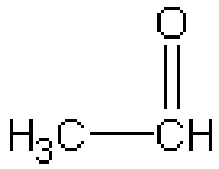
1. Draw the following:

a) 2-methylpropanal

b) 4-methyl-2-pentenal

2. Name the following:

a)



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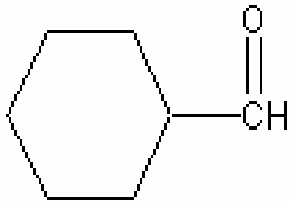

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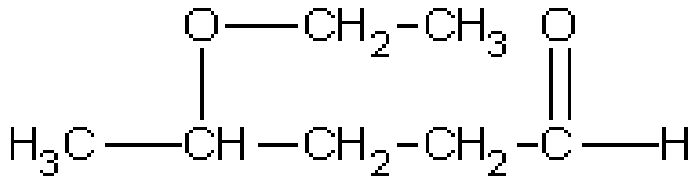


Ketones R-CO-R′

Contains a "carbonyl group" attached between 2 carbon atoms. The rules:

i) Name the longest carbon chain with the carbonyl group using the appropriate prefix and add the suffix "____" to the end of the name.

ii) If the carbon chain is more than 4 carbons indicate the position number of the carbonyl group so that it has the lowest number.

iii) If there is more than one carbonyl group add the suffix dione (2) or trione (3)

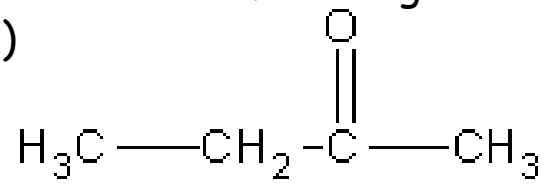
1. Draw the following:

a) 4-methyl-2-pentanone

b) b) 4-methyl-3-cyclopropyl-2-pentanone

2. Name the following:

a)



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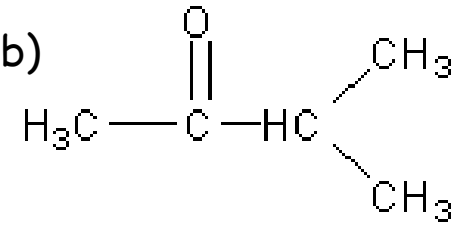


Properties of Aldehydes & Ketones

- aldehydes & ketones have _____ boiling point's than analogous alcohols and are _____ soluble in water as they don't have OH groups and _____ participate in H bonding
- _____ is a strongly polar group so that they are both more soluble in water than are hydrocarbons
- Are good solvents because they will mix with _____ polar and non-polar substances

Table 1 Boiling Points of Analogous Compounds

Compound	Structure	Boiling point (°C)
ethanol	CH_3CH_2OH	78
ethanal	CH_3CHO	21
1-propanol	$CH_3CH_2CH_2OH$	97
propanal	CH_3CH_2CHO	49
propanone	CH_3COCH_3	56
1-butanol	$CH_3CH_2CH_2CH_2OH$	118
butanal	$CH_3CH_2CH_2CHO$	75
butanone	$CH_3CH_2COCH_3$	80

Chemical Reactions of Aldehydes and Ketones

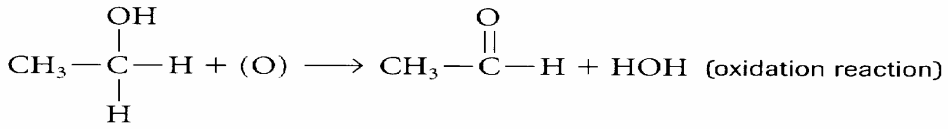
A) Preparing Aldehydes and Ketones

Aldehydes and ketones can be prepared by the controlled oxidation of alcohols.

In organic chemistry the term "_____" generally implies the _____ of O atoms or the loss of H atoms. Another clue is when carbon atoms forms more bonds to O atoms or less bonds to H atoms.

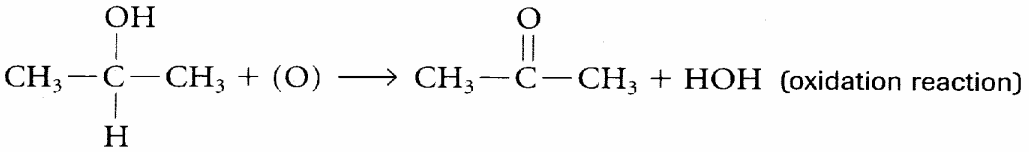
Oxidation Reactions

primary alcohol + oxidizer → aldehyde



ethanol (1° alcohol) ethanal

secondary alcohol + oxidizer → ketone



2-propanol (2° alcohol) propanone

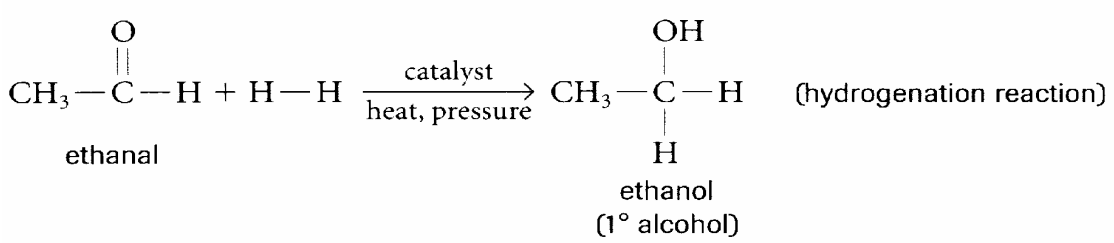
tertiary alcohol undergoes no reaction (no H atom available on central C atom)

C) tertiary alcohol (oxidizer) → no reaction (no H atom available on central C atom)

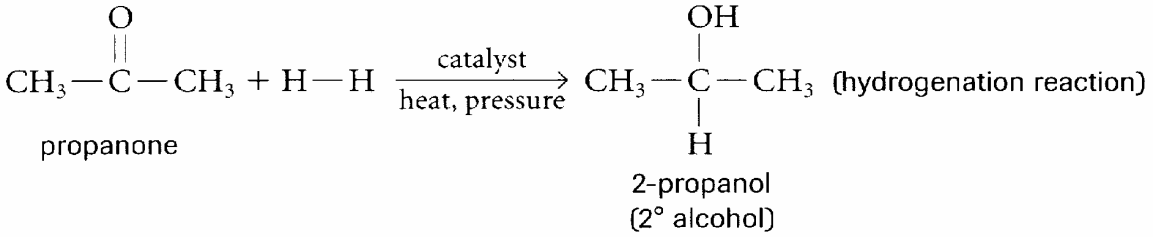
B) Other Reactions Involving Aldehydes and Ketones

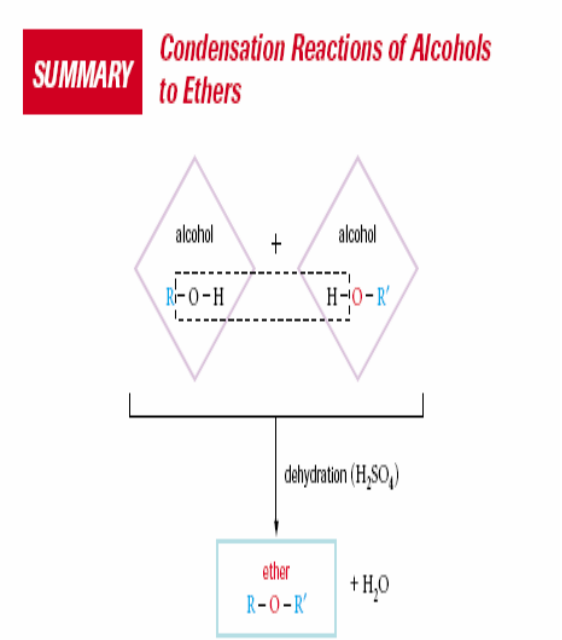
_____ (hydrogenation addition)

aldehydes + hydrogen → primary alcohol



ketones + hydrogen → secondary alcohol





SUMMARY *Ethers*

Functional group: R–O–R′

Preparation:

- alcohols → ethers + water

  Condensation reaction, eliminating H_2O; dehydration

  $R{-}OH + R'{-}OH \rightarrow R{-}O{-}R' + H{-}OH$

Amines R -- NH_2

Contains a amine group ($-NH_2$), a derivative of _____ (NH_3) in which hydrogen has been replaced by a alkyl group
The rules:

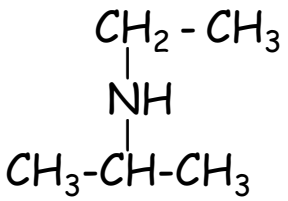
i) Name according to longest carbon chain attached to the nitrogen atom and add the suffix "_____"
ii) Name the other alkyl groups attached to the nitrogen atom. Use the letter "N" to locate the groups and "N,N-" to indicate that two identical alkyl groups are attached to the nitrogen atom.

1. Draw the following:

a) 2,2-dichloro-3-pentanamine b) N-methyl-2-propanamine

2. Name the following:

a)



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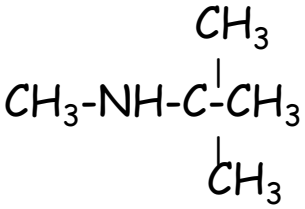


Classification of Amines

The meanings of the following terms are slightly different from alcohols

a) Primary Amines

Has _____ alkyl group and two hydrogen atoms attached to the nitrogen atom.

e.g. ethanamine

b) Secondary Amines

Has _____ alkyl groups and one hydrogen atom attached to the nitrogen atom.

e.g. N-methyl,ethanamine

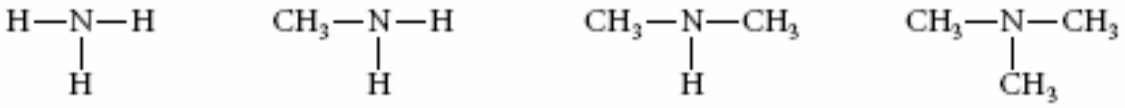
c) Tertiary Amines

Has _____ alkyl groups attached to the nitrogen atom.

e.g. N-ethyl,N-methyl-ethanamine

Properties of Amines

- amines have higher boiling points and melting points than hydrocarbons of the same size and smaller amines are soluble in water due to N-C and N-H both of which are polar



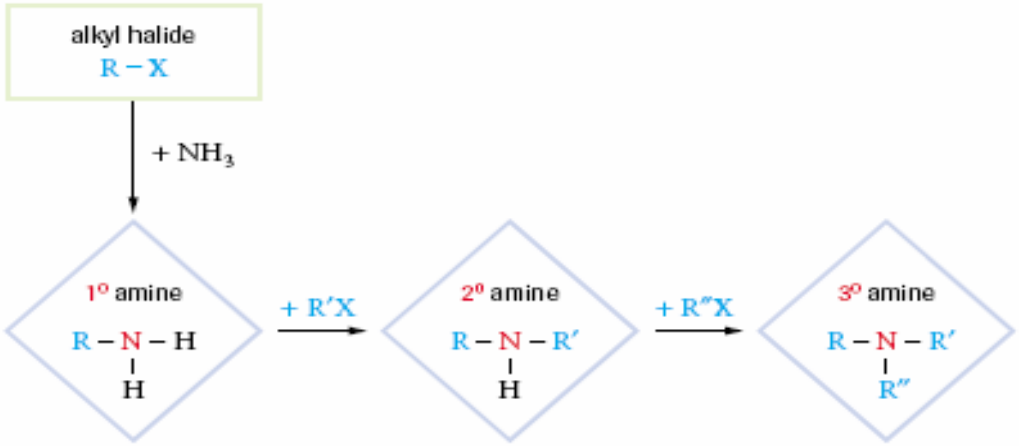
b.p. −33°C b.p. −6°C b.p. 8°C b.p. 3°C

- when N-H bonds are present, hydrogen bonding _____ occur with water which explains the high solubility of amines in water
- N-H bonds are _____ polar than O-H so amines will boil at lower temperature

Table 2 Boiling Points of Analogous Hydrocarbons, Amines, and Alcohols

Hydrocarbon	b.p. (°C)	Amine	b.p. (°C)	Alcohol	b.p. (°C)
CH_3CH_3	−89	CH_3NH_2	−6	CH_3OH	65
$C_2H_5CH_3$	−42	$C_2H_5NH_2$	16	C_2H_5OH	78
$C_3H_7CH_3$	-0.5	$C_3H_7NH_2$	48	C_3H_7OH	97
$C_4H_9CH_3$	36	$C_4H_9NH_2$	78	C_4H_9OH	117

SUMMARY *Synthesizing Amines from Alkyl Halides*



Carboxylic Acids R-COOH

Contains a "carboxyl group" (--COOH) attached to the end of a hydrocarbon chain. The rules:

i) Name according to longest carbon chain and add the suffix "_____".

ii) The carbon atom of the carboxyl group always given the position # 1.

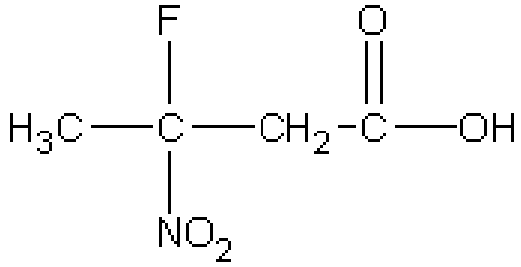
1. Draw the following:

a) 4-ethyl-3- methylheptanoic acid

b)4-phenyl-6- cyclobutylhexanoic acid

2. Name the following:

a)



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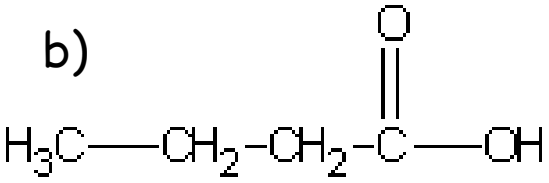


Properties of Carboxylic Acids & Esters

- organic acids have a carboxyl functional group –COOH and are called carboxylic acids

- like inorganic acids, carboxylic acids can react with OH containing compounds to form an organic "salt" called an ____

- Carboxylic Acids are generally _____ acids, are found in citrus fruits, crab apples, rhubarb, and other foods known by their sour tangy taste

- carboxylic acids also have _____ odours that can be used in law enforcement

- due to C=O and OH groups in carboxyl groups these molecules are _____ and can form _____ with each other and water molecules

- smaller acids have similar solubility to alcohols but larger ones are relatively _____

- carboxylic acids have the properties of acids and can react organic "bases" to form "salts"

- due to intermolecular attractions between the carboxyl functional groups the melting points are _____ than their corresponding hydrocarbons

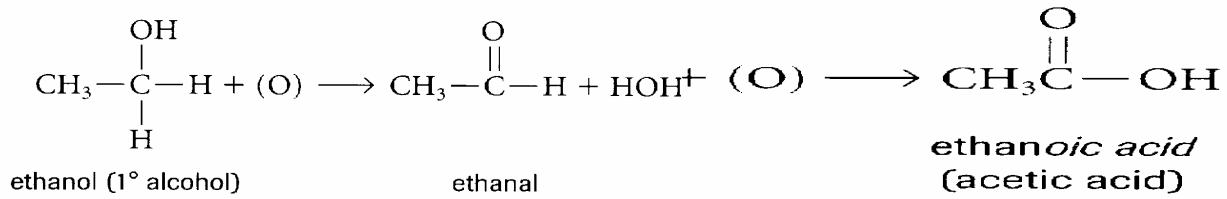
Table 1 Melting Points of Some Carboxylic Acids and Their Parent Alkanes

Number of C atoms	Number of COOH groups	Compound	Melting point (°C)
1	0	methane	−182
1	1	methanoic acid	8
2	0	ethane	−183
2	1	ethanoic acid	17
2	2	oxalic acid	189
4	0	butane	−138
4	1	*n*-butanoic acid	-8
4	2	tartaric acid	206
6	0	hexane	−95
6	1	hexanoic acid	13
6	3	citric acid	153

Chemical Reactions of Carboxylic Acids

A) Preparation of Carboxylic Acids

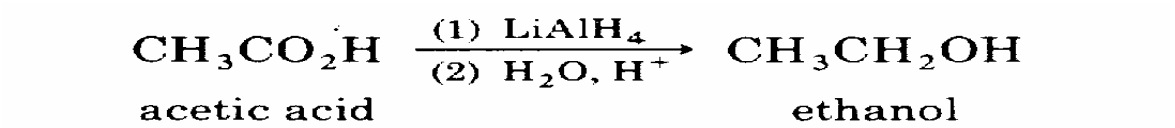
Oxidation Reactions

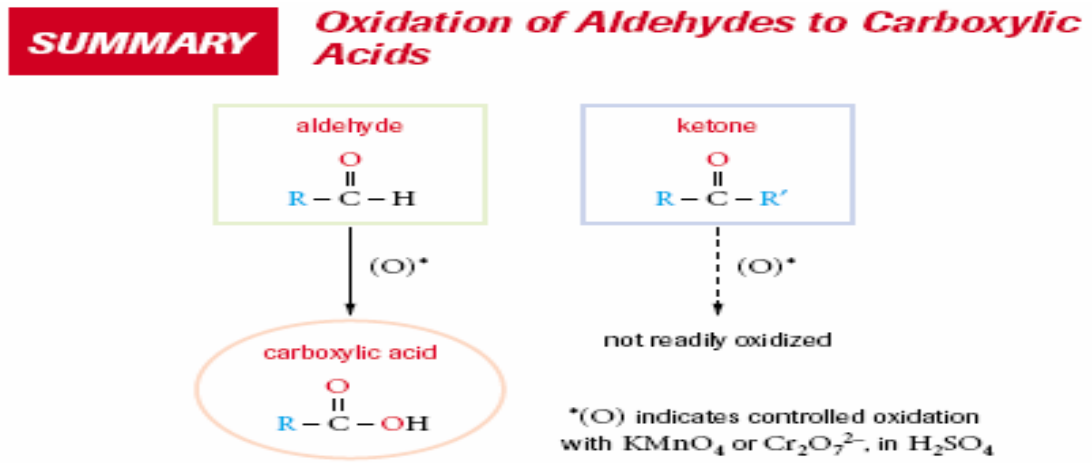


B) Other Reactions Involving Carboxylic Acids

Reduction Reactions

- Carboxylic acids are _____ to most common reducing agents (such as hydrogen plus a catalyst). $LiAlH_4$ is capable of reducing a carbonyl group directly to $-CH_2OH$.





Independent Assignment:
Ester Linkage and Amide Linkage

Read pg's 44 - 48 and 76 in your text.

Part A: Esters (inorganic salts)

1. What is an ester?
2. Briefly summarize the rules for naming esters
3. Complete the physical/chemical properties section in your table.
5. Using structural formula summarize the following reactions involving esters under the following headings:

A) Preparation of Esters (Condensation):

i) Neutralization (carboxylic acids and bases)
ii) Esterfication (carboxylic acids and alcohols)

B) Other Reactions Involving Esters (Hydrolysis)

i) Hydrolysis (acidic) (just briefly describe)
ii) Hydrolysis (basic), also called saponification

Part B: Amides

1. What is an amide?
2. Briefly summarize the rules for naming amides
3. Complete the physical/chemical properties section in your table.
5. Using structural formula summarize the following reactions involving amides under the following heading:

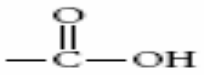
Reactions Involving Amides :

i) Hydrolysis (acidic)
ii) Hydrolysis (basic), (just briefly describe)

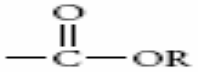
SUMMARY ***Carboxylic Acids and Esters***

Functional groups:

- carboxylic acid: —COOH carboxyl group



- ester: —COOR alkylated carboxyl group



Preparation:

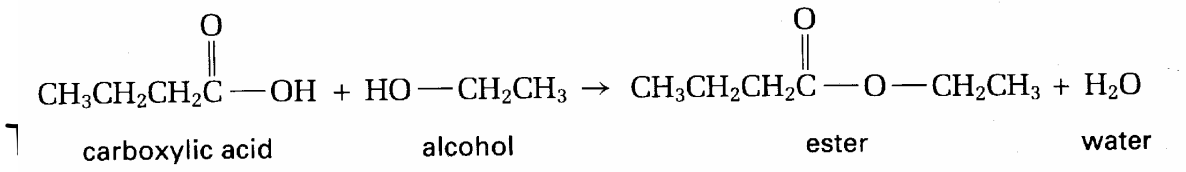
- alcohol + (O) → aldehyde + (O) → carboxylic acid
  oxidation reaction; add (O)
- carboxylic acid + alcohol → ester + H_2O
  condensation reaction

Pathway to other compounds:

- ester + NaOH → sodium salt of acid + alcohol
  hydrolysis; saponification

Ester Linkage R-COOR'

Contains a "_____ group" (--COOH) attached between carbon atoms. Can be formed when a carboxylic acid reacts with an _____.



i) Name according to longest carbon chain containing the C=O and replace the "____ _____" ending of the parent acid with "_____". Write this second

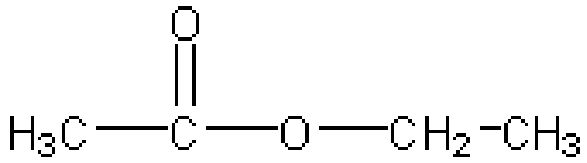
ii) Name the attached alkyl group first.

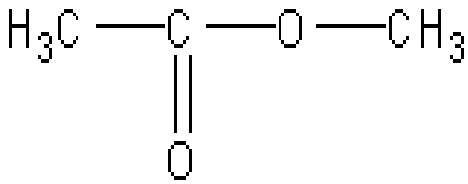
1. Draw the following:

a) ethyl-2-chloroethanoate b) butyl ethanoate

2. Name the following:

a) b)





Amide Linkage $R\text{-}CO\text{-}NR_2$

Formed when an _____ reacts with a _____ acid.

The rules:

i) Name according to longest carbon chain containing the C=O and

replace the "_____ _____" ending of the parent acid with "-_____".

Write this second

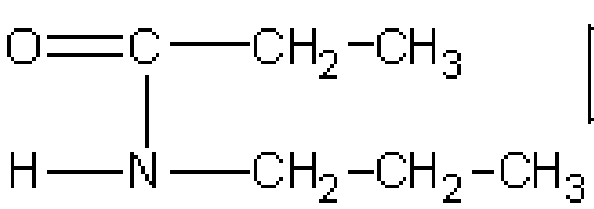
ii) If one alkyl group attached to N atom, add N- and location #. If two alkyl groups, place in alphabetical order and add N- if different and N,N- if two groups are the same.

1. Draw the following:

a) N-methyl-2,methylpropanamide b) N-methylpropanamide

2. Name the following:

a)



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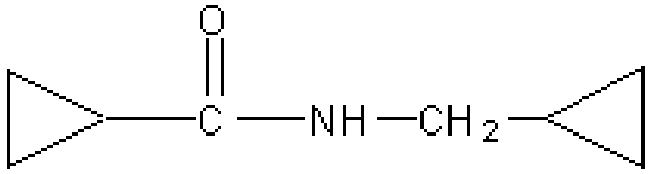

Polymers

Polymer:

A long molecule formed from linking together many smaller repeating units called _____.

Natural polymers include: starch, cotton wool etc.
e.g. starch

Synthetic polymers include: rayon, polystyrene, nylon
e.g. Polystyrene

Polymerization

1. Addition Polymerization

A reaction in which monomers with double bonds are joined together through multiple addition reactions. e.g. polyethene

2. Condensation Polymerization

A reaction in which monomers are joined together by the formation of ester or amide bonds and the release of water. Nylons or polyamides contain amide linkages and polyesters contain ester bonds e.g. Nylon-66

Independent Assignment: Polymerization

1. Under the heading "Addition Polymerization" copy table 2.1 on pg. 83.
2. Under the heading "Condensation Polymerization" copy table 2.2 on pg. 84
3. Answer pp # 18-22, pg's 84-85
   sr # 1-3, pg. 95