Unit 3: Organic Chemistry

Section 3.1 – 3.21
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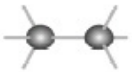
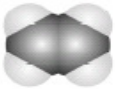
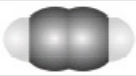
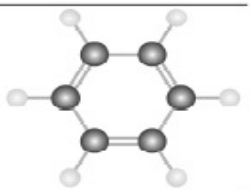
3.1 Hydrocarbons 1

Term	Definition
	An organic compound that contains only carbon and hydrogen atoms in its molecular structure.
Alkane	
	A hydrocarbon that contains at least one C=C double bond; general formula: C_nH_{2n}
Alkyne	

Table 1 Examples of Hydrocarbons

Hydrocarbon group	Example	Formula	Spacefill diagram	Bond and angles diagram
Aliphatic				
alkane	ethane	CH_3CH_3		
	cyclohexane	C_6H_{12}		
alkene	ethene	CH_2CH_2		
alkyne	ethyne	CHCH		
Aromatic				
	benzene	C_6H_6		

Hydrocarbons 2

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-	$-C_{10}H_{21}$

Propane is a fuel that is commonly used in gas barbecues. Draw a structural formula for propane, and write its formula.

Step 1: Write Carbon Backbone of Appropriate Length

Step 2: Add single Lines to Each Carbon, to a Total of Four Lines

Step 3: Fill Remaining Bonds with Hydrogen Atoms

Butane **Octane** **Methane**

Hydrocarbons 3

Draw a structural formula and write the molecular formula for 1-hexene

Step 1: Write Carbon Backbone of Appropriate Length

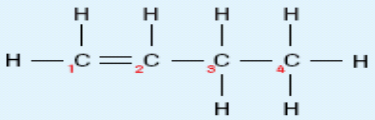
Step 2: Establish Location of Double Bond

Step 3: Fill Remaining Bonds with Hydrogen Atoms

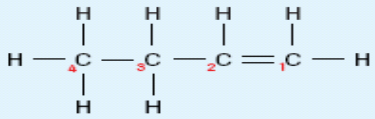
****Use the lowest number** – The carbon backbone of alkenes and alkynes is not always numbered from the left. Check the location of the double or triple bond before deciding how to number the carbon atoms.**

Write the IUPAC name and the molecular formula for each of the following alkenes:

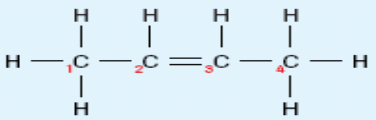
(a)



(b)



(c)



Draw a structural formula and write the molecular formula for each of the following hydrocarbons: a) ethane, b) ethyne, c) 2-hexene

Reactions of Hydrocarbons

Complete Combustion:

hydrocarbon + oxygen ⟶ carbon dioxide + water

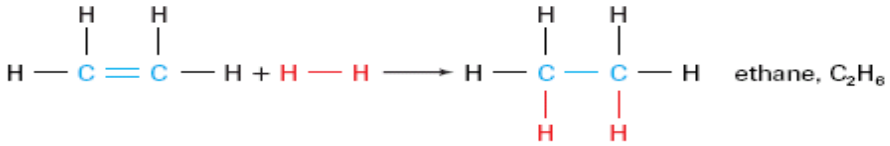
Write a balanced chemical equation to represent the complete combustion of 1-hexene. Use a condensed structural formula to represent 1-hexene.

Step 1: Write Word Equation for Reaction

Step 2: Write Chemical Formulas

Step 3: Balance Equation

Term	Definition
	A reaction of an alkene / alkyne in which a molecule, such as hydrogen or a halogen, is added to a double / triple bond
Unsaturated	
	Containing only single C-C bonds



Draw a structural formula equation for each of the following addition reaction: **2-butene and water, H_2O**

Fractional Distillation & Cracking

Term	Definition
	A mixture of gases and liquids, composed of hydrocarbon molecules up to 40 C atoms long
Fractional Distillation	
	The process in which large straight-chain hydrocarbon molecules are converted into smaller branched-chain hydrocarbon molecules, usually by catalytic heating

Table 1 Uses of Hydrocarbons

Number of C atoms	Boiling point	End use
1–5	under 30°C	fuels for heat and cooking
5–6	30°C–90°C	camping fuel and dry-cleaning solvents
5–12	30°C–200°C	gasoline
12–16	175°C–275°C	kerosene and diesel fuel
15–18	250°C–375°C	furnace oil
16–22	over 400°C	heavy greases for lubricating
over 20	over 450°C	waxes, cosmetics, and polishes
over 26	over 500°C	asphalt and tar for roofs and roads

Fraction Distillation & Cracking 2

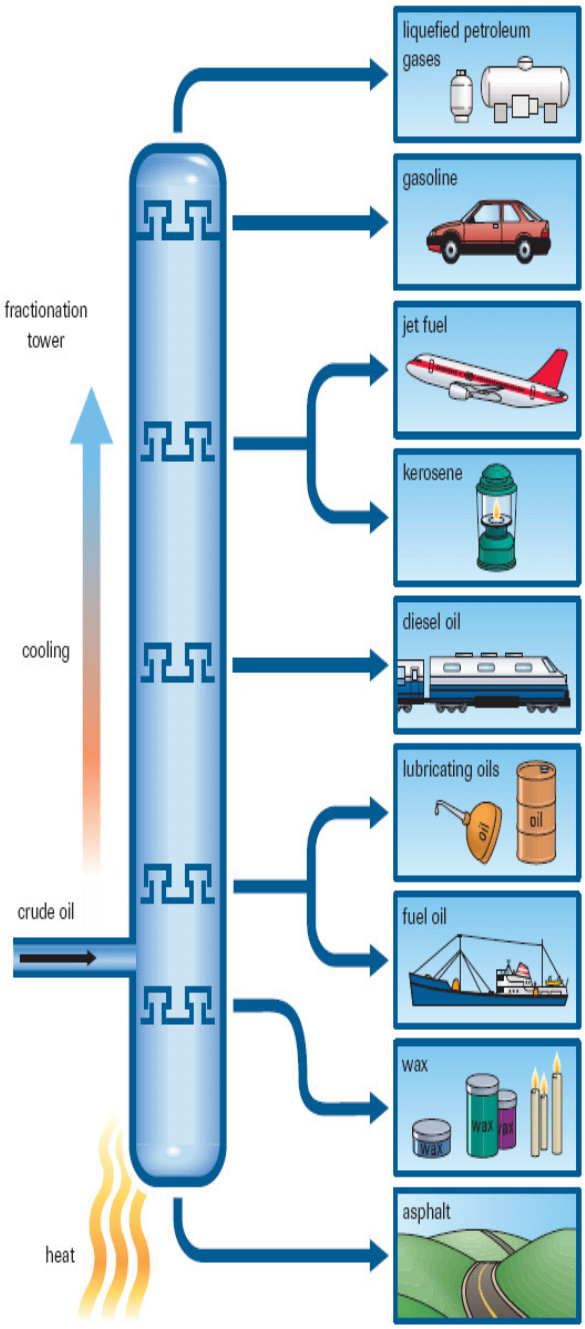


Figure 4
The higher the octane number of a gasoline, the more efficiently the gasoline burns to produce power and, thus, the less "knocking" in the engine. Highly branched alkanes have high octane numbers. For example, iso-octane is assigned an octane number of 100, while straight-chain heptane is assigned an octane number of 0.

Functional Groups

Term	Definition
	A group of organic compounds with common structural features that share chemical and physical properties
Functional group	
	An intermolecular attraction between -OH and -NH groups in different molecules

(a)

— C ═ C —

carbon–carbon double bond

(b)

— OH

hydroxyl group

(c)

— N —

amine group

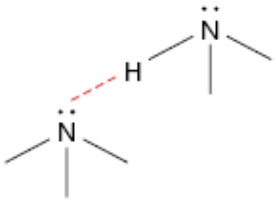
(d)

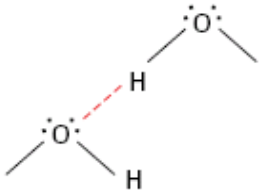
— C ═ O

carbonyl group

Table 1 Electronegativities of Common Elements

Element	Electronegativity
H	2.1
C	2.5
N	3.0
O	3.5





SUMMARY Functional Groups

Double and triple bonds between carbon atoms:

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

A carbon atom bonded to a more electronegative atom (oxygen, nitrogen, or a halogen):

C–O C–N C–Cl, C–Br, C–F	Unequal sharing of electrons results in a polar bond, increasing intermolecular attraction and raising the boiling point and melting point of the compound.

A carbon atom double-bonded to an oxygen atom:

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

Alcohols & Ethers

Term	Definition
	An organic compound that is characterized by the presence of a hydroxyl functional group; general formula: **R-OH**
Ether	
	A substitution group or branch from a hydrocarbon; general formula: **R**

HOH
water

ROH
alcohol
example: CH_3OH

ROR
ether
example: $CH_3–O–CH_3$

Draw the structural formula and write the formula for 1-butanol

Step 1: Draw Carbon Backbone

Step 2: Add –OH Group in Appropriate Position

Step 3: Complete Remaining Bonds with H atoms

Table 1 Alkyl Groups

Alkyl group	Alkyl formula
methyl-	$–CH_3$
ethyl-	$–C_2H_5$
propyl-	$–C_3H_7$
butyl-	$–C_4H_9$
pentyl-	$–C_5H_{11}$
hexyl-	$–C_6H_{13}$
heptyl-	$–C_7H_{15}$
octyl-	$–C_8H_{17}$
nonyl-	$–C_9H_{19}$
decyl-	$–C_{10}H_{21}$

Alcohols & Ethers 2

Properties of Alcohols

Table 3 Boiling Points of Alcohols

Name	Formula	Boiling point (°C)
methanol	CH_3OH	65
ethanol	C_2H_5OH	78
1-propanol	C_3H_7OH	97
1-butanol	C_4H_9OH	117

Properties of Ethers

Table 4 Boiling Points of Similar Compounds

Compound	Structure	Boiling point (°C)
ethane	$CH_3–CH_{3(g)}$	–89
methoxymethane (dimethyl ether)	$CH_3–O–CH_{3(g)}$	–23
ethanol	$CH_3–CH_2–O–H_{(l)}$	78.5
water	$H–O–H_{(l)}$	100

Naming Ethers

Name the following ether: a) $CH_3OCH_2CH_3$

Step 1: Add "*oxy*" to the prefix of the smaller hydrocarbon

Step 2: Join the new prefix to the alkane name of the larger hydrocarbon group.

b) Methoxymethane

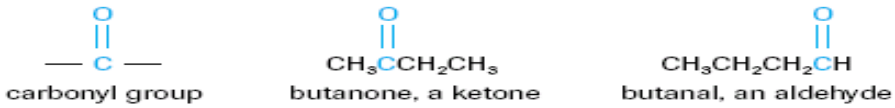
c) butoxypentane

Aldehydes & Ketones

Term	Definition
	An organic compound in which the carbon atom of a carbonyl group is bonded to two carbon atoms
Aldehyde	
	A functional group that contains a carbon atom joined to an oxygen atom with a double covalent bond; general formula: **C=O**

General formulas:

Structural formulas:

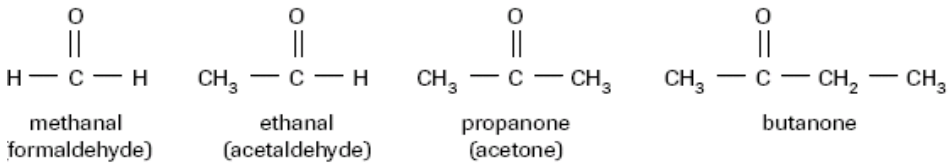


Naming Aldehydes

Step 1: take the parent alkane name, drop the final –e, and add -al

Naming Ketones

Step 1: replace the –e ending of the parent alkane name with -one



Carboxylic Acids

Term	Definition
	An organic compound that is characterized by the presence of a caroxyl group; general formula: **R-COOH**
Carboxyl group	

Naming Carboxylic Acids

Step 1: Identify the number of atoms in the longest carbon chain

Step 2: Take off the –e ending and replace with "anoic acid"

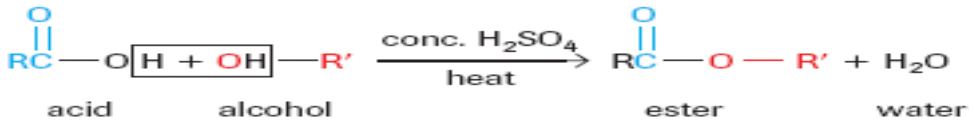
Table 1 Melting Points of Some Carboxylic Acids

Number of COOH groups	Carboxylic acid	Melting point (°C)
1	methanoic acid	8
1	ethanoic acid	17
2	oxalic acid	189

Esters

Term	Definition
	An organic compound that is characterized by the presence of a carbonyl group bonded to an oxygen atom
Esterification	
	A reaction in which a bond is broken by the addition of water, resulting in the formaiton of two or more products.

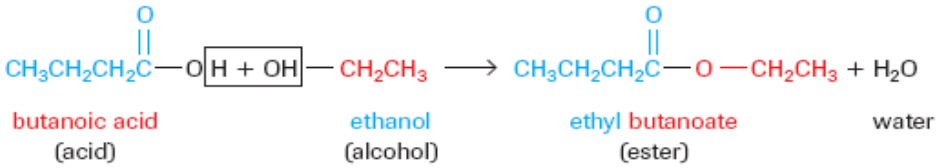
Esterification



Naming Esters

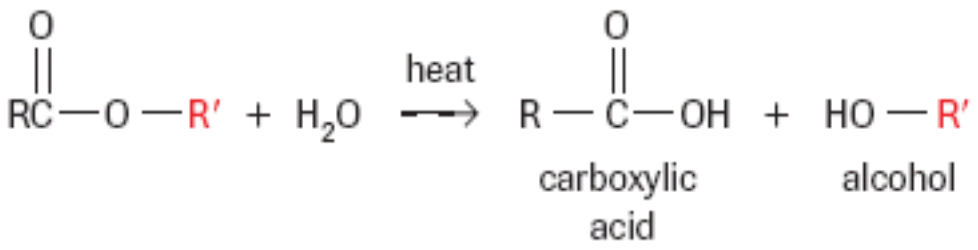
The name of the ester has two parts. The **first** part comes from the **alcohol** and the **second** part comes from the **carboxylic acid**

The ending of the acid name is changed from **–anoic acid** to **–anoate**

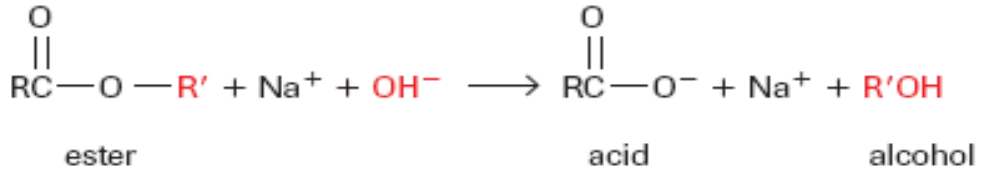


Esters 2

Hydroylsis

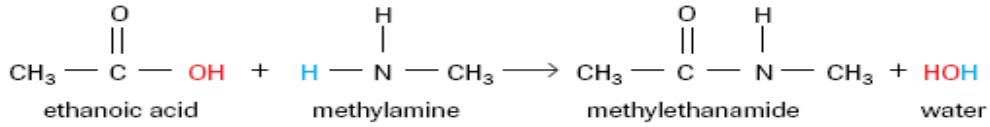


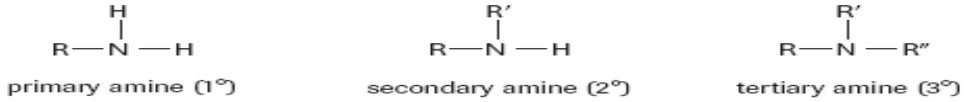
fats or oils (esters) + NaOH $\xrightarrow{\text{heat}}$ soap + alcohol



Amines & Amides

Term	Definition
	An organic compound in which one or more hydrogen atoms are replaced by alkyl groups
Amide	





Naming Amines

Step 1: add the prefix "amino"

Step 2: identify the longest-chain hydrocarbon.

Naming Amides

Step 1: similar to naming esters. While esters end in –oate, amides end in -amide

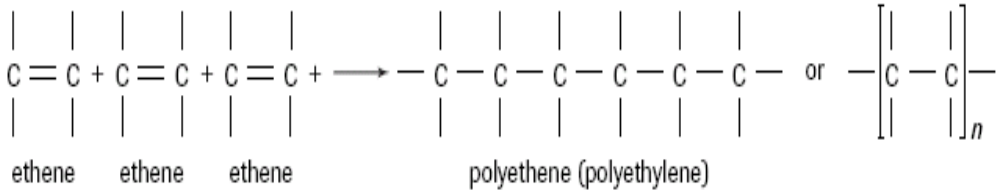
butanoic acid + aminomethane → methyl butanamide + water
(an amide)

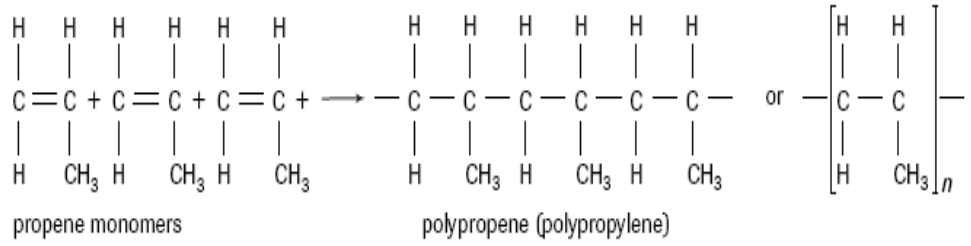
Table 1 Boiling Points of Corresponding Hydrocarbons, Amines, and Alcohols

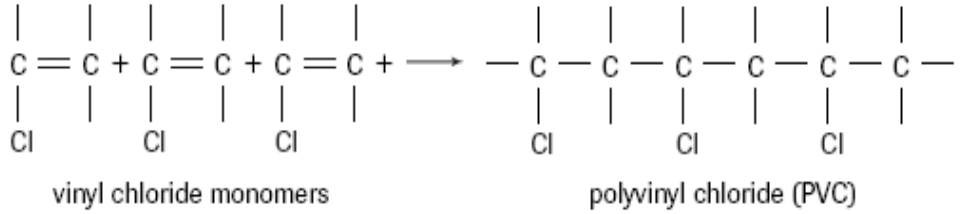
Hydrocarbon	b.p. (°C)	Amine	b.p. (°C)	Alcohol	b.p. (°C)
CH_3CH_3	−89	CH_3NH_2	−6	CH_3OH	65
$C_2H_5CH_3$	−42	$C_2H_5NH_2$	16	C_2H_5OH	78
$C_3H_7CH_3$	−0.5	$C_3H_7NH_2$	48	C_3H_7OH	97
$C_4H_9CH_3$	36	$C_4H_9NH_2$	78	C_4H_9OH	117

Polymers

Term	Defintion
	A synthetic substance that can be moulded (under heat and pressure) and retains the shape it is moulded into
Polymer	
	A polymer that is formed when monomer units are linked through addition reactions; all atoms in the monomer are retained in the polymer
Monomer	







Condensation Polymers

Term	Definition
	Covalent bonds that form between polymer chains
Polyester	
	A polymer that is formed by condensation reactions resulting in amide linkages between monomers
Condensation polymer