L2 - Learning Outcomes

11.1 Formulae, functional groups and terminology

I can:

- ❑ 1. Draw and interpret the displayed formula of a molecule to show all the atoms and all the bonds
- ❑ 2. Write and interpret general formulae of compounds in the same homologous series, limited to:
  (a) alkanes, C_nH_{2n+2}
  (b) alkenes, C_nH_{2n}
  (c) alcohols, $C_nH_{2n+1}OH$
  (d) carboxylic acids, $C_nH_{2n+1}COOH$
- ❑ 3. Identify a functional group as an atom or group of atoms that determine the chemical properties of a homologous series
- ❑ 4. State that a homologous series is a family of similar compounds with similar chemical properties due to the presence of the same functional group
- ❑ 5. State that a saturated compound has molecules in which all carbon–carbon bonds are single bonds
- ❑ 6. State that an unsaturated compound has molecules in which one or more carbon–carbon bonds are not single bonds
- ❑ 7. State that a structural formula is an unambiguous description of the way the atoms in a molecule are arranged, including $CH_2=CH_2$, CH_3CH_2OH, CH_3COOCH_3

- ❑ 9 Describe the general characteristics of a homologous series as:
  (a) having the same functional group
  (b) having the same general formula
  (c) differing from one member to the next by a –CH2– unit
  (d) displaying a trend in physical properties
  (e) sharing similar chemical properties

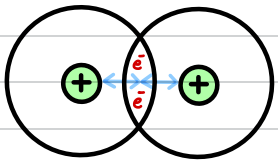
11.2 Naming organic compounds

I can:

- ❑ 1. Name and draw the displayed formulae of:
  (a) methane and ethane
  (b) ethene
  (c) ethanol
  (d) ethanoic acid

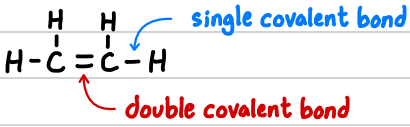
- ❑ 2. State the type of compound present, given a chemical name ending in -ane, -ene, -ol, or -oic acid or from a molecular formula or displayed formula
- ❑ 3. Name and draw the structural and displayed formulae of unbranched:
  (a) alkanes
  (b) alkenes, including but-1-ene and but-2-ene
  (c) alcohols, including propan-1-ol, propan-2-ol, butan-1-ol and butan-2-ol
  (d) carboxylic acids containing up to four carbon atoms per molecule

Functional groups and Homologous series



Recall: covalent bond is the electrostatic attraction between positive nuclei and shared pair of electrons

※ represented by a solid line



Functional group : atom or group of atoms that determine the chemical properties of a homologous series

Homologous series : family of compounds that have the same general formula and similar properties but differ by number of carbon atoms

↳ same functional group ↳ same general formula ↳ similar chemical properties ↳ trend in physical properties

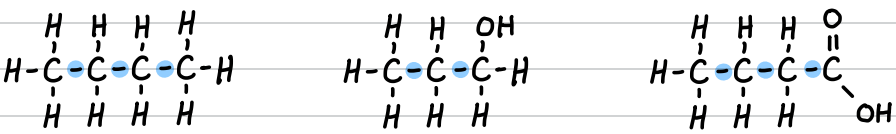
Homologous series	functional group		general formula
alkanes	none	only C-C	C_nH_{2n+2}
alkenes	alkenyl	C=C in chain	C_nH_{2n}
alcohols	hydroxyl	-OH in chain	$C_nH_{2n+1}OH$
carboxylic acids	carboxyl	$-\overset{O}{\overset{\|}{C}}-OH$	at terminal $C_nH_{2n+1}COOH$

↳ members of a homologous series differ from each other by one CH_2 unit

number of C	alkanes	alkenes	alcohols	carboxylic acids
1	CH_4	—	CH_2OH	$HCOOH$
2	CH_3CH_3	CH_2CH_2	CH_3CH_2OH	CH_3COOH
3	$CH_3CH_2CH_3$	CH_2CHCH_3	$CH_3CH_2CH_2OH$	CH_3CH_2COOH
4	$CH_3CH_2CH_2CH_3$	$CH_2CHCH_2CH_3$	$CH_3CH_2CH_2CH_2OH$	$CH_3CH_2CH_2COOH$
5	$CH_3CH_2CH_2CH_2CH_3$	$CH_2CHCH_2CH_2CH_3$	$CH_3CH_2CH_2CH_2CH_2OH$	$CH_3CH_2CH_2CH_2COOH$

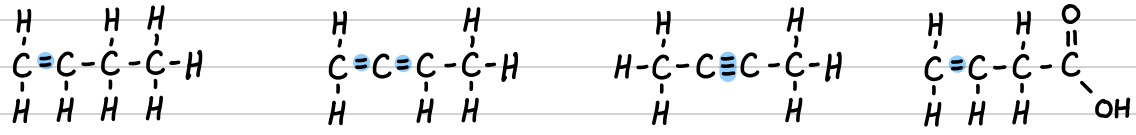
Saturated compounds : molecule where all carbon-carbon bonds are single bonds

ex:



Unsaturated compounds : molecule where one or more carbon-carbon bonds are not single bonds

ex:



Naming organic compounds

IUPAC nomenclature : system of naming organic molecules based on structure and functional groups
↳ International Union of Pure and Applied Chemicals

Prefix — number of carbons in main chain

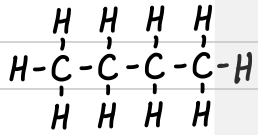
meth = 1	C	pent = 5	C-C-C-C-C	non = 9	C-C-C-C-C-C-C-C-C
eth = 2	C-C	hex = 6	C-C-C-C-C-C	dec = 10	C-C-C-C-C-C-C-C-C-C
prop = 3	C-C-C	hept = 7	C-C-C-C-C-C-C		
but = 4	C-C-C-C	oct = 8	C-C-C-C-C-C-C-C		

Suffix — functional group

- alkane = ane
- alkene = - # - ene ※ # is the position of double bond (C=C)
- alcohol = an- # - ol ※ # is the position of hydroxyl (-OH)
- carboxylic acid = anoic acid

Alkanes

↳ from structural formula : count number of carbons = prefix + ane

ex:  4 C = but + ane **butane**

same process

↳ from chemical formula : confirm C_nH_{2n+2} / draw structural formula
n = prefix + ane

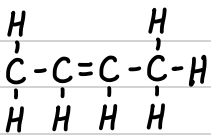
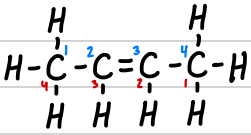
ex: C_8H_{18} $2n+2 = 18$ $\therefore n = 8$ confirmed **octane**

↳ from skeleton structural formula : count number of points + 2 ends = prefix + ane

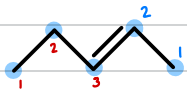
ex:  3 points + 2  **pentane**

Alkenes

↳ from structural formula :
1. count number of carbons = prefix
2. if >3 determine carbon number where C=C is ※ lowest number
3. prefix-#-ene

ex:   **but-2-ene**

↳ from skeleton structural formula :
1. count number of points + 2 ends = prefix
2. if >3 determine carbon number where C=C is ※ lowest number
3. prefix-#-ene

ex:   **pent-2-ene**

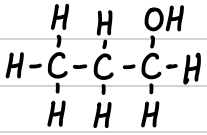
Naming organic compounds

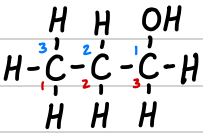
Alcohols (of alkanes)

↳ from structural formula:

1. count number of carbons = prefix + an
2. determine carbon number where -OH is ※ lowest number
3. prefix-#-ol

ex:



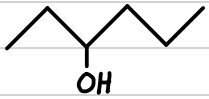


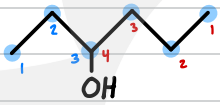
propan-1-ol

↳ from skeleton structural formula:

1. count number of points + 2 ends = prefix + an
2. determine carbon number where -OH is ※ lowest number
3. prefix-#-ol

ex:



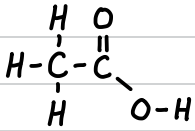


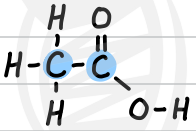
hexan-3-ol

Carboxylic acids (of alkanes)

↳ from structural formula: count number of carbons = prefix + anoic acid

ex:





2C = eth

ethanoic acid

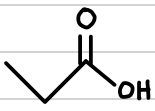
↳ from chemical formula: $C_nH_{2n+1}COOH$

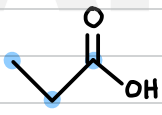
n+1 = prefix + anoic acid

ex: C_4H_9COOH n=4+1 = 5 pentanoic acid

↳ from skeleton structural formula: count number of points + 1 end (without OH) = prefix + anoic acid

ex:





2 points + 1 end = 3

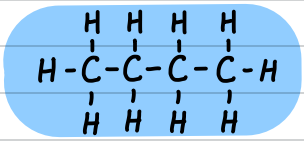
propanoic acid

Drawing organic compounds

Alkanes

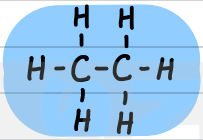
↳ from the name:
1. prefix = draw that many C and connect each C with single bond
2. connect each C with H until it forms 4 bonds

ex: butane — but = 4 — C C C C — C-C-C-C



↳ from the formula:
1. C_n n = number of carbons
2. draw that many C and connect each C with single bond
3. draw remaining H

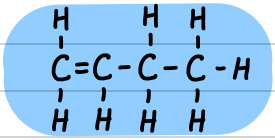
ex: C_2H_6 — C C — C-C



Alkenes

↳ from the name:
1. prefix = draw that many C.
2. draw double bond on C at the designated number
3. draw single bonds connecting rest of C.
4. connect each C with H until it forms 4 bonds

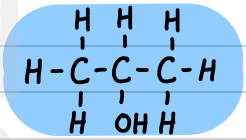
ex: but-1-ene — C C C C — C=C C C — C=C-C-C



Alcohols

↳ from the name:
1. prefix = draw that many C.
2. draw -OH on C at the designated number
3. draw single bonds connecting rest of C.
4. connect each C with H until it forms 4 bonds

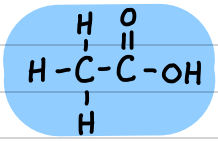
ex: propan-2-ol — C C C — C C C (OH) — C-C(OH)-C



Carboxylic acids

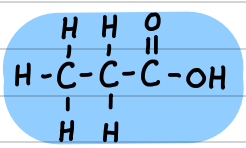
↳ from the name:
1. prefix = draw that many C.
2. draw -COOH to C on one end
3. draw single bonds connecting rest of C.
4. connect each C with H until it forms 4 bonds

ex: ethanoic acid — C C — C C(=O)-OH — C-C(=O)-OH



↳ from the formula:
1. C_n n = number of carbons - draw that many C
2. draw COOH
3. connect each C with single bond
4. draw remaining H

ex: C_2H_5COOH — C C — C C C(=O)-OH — C-C-C(=O)-OH



Deducing chemical formulae of organic compounds

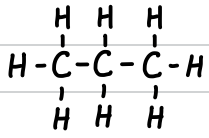
Alkanes

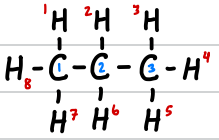
↳ from the name: ① prefix = n ② use formula C_nH_{2n+2}

ex: methane meth = 1 $C_{(1)}H_{2(1)+2}$ CH_4

↳ from the structural formula: count number of C and H

ex:





C_3H_8

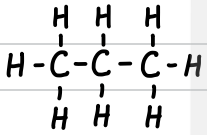
Alkenes

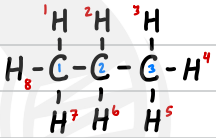
↳ from the name: ① prefix = n ② use formula C_nH_{2n}

ex: ethene eth = 2 $C_{(2)}H_{2(2)}$ C_2H_4

↳ from the structural formula: count number of C and H

ex:





C_3H_8

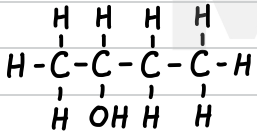
Alcohols

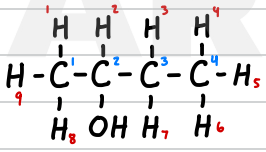
↳ from the name: ① prefix = n ② use formula $C_nH_{2n+1}OH$

ex: butan-1-ol but = 4 $C_{(4)}H_{2(4)+1}OH$ C_4H_9OH

↳ from the structural formula: ① count number of C and H (not including OH) ② add OH

ex:





C_4H_9OH

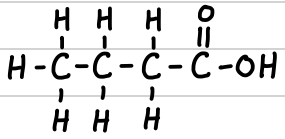
Carboxylic acids

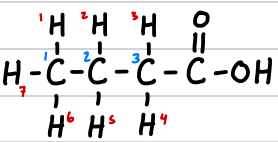
↳ from the name: ① prefix = n-1 ② use formula $C_nH_{2n+1}COOH$

ex: methanoic acid meth = 1-1 $C_{(0)}H_{2(0)+1}COOH$ $HCOOH$

↳ from the structural formula: ① count number of C and H (not including COOH) ② add COOH

ex:





C_3H_7COOH

Summary

Alkanes

number of C	name	chemical formula	structural formula
1			
2			
3			
4			
5			

Carboxylic acids

number of C	name	chemical formula	structural formula
1			
2			
3			
4			
5			

Summary

Alkenes

number of C	name	chemical formula	structural formula
2			
3			
4			
4			
5			
5			

Summary

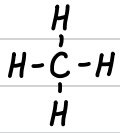
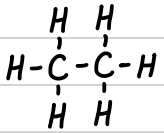
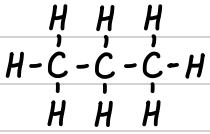
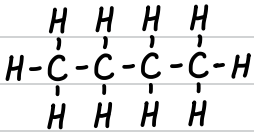
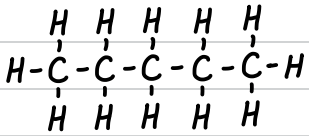
Alcohols

number of C	name	chemical formula	structural formula
1			
2			
3			
3			
4			
4			
5			
5			
5			

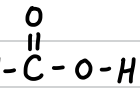
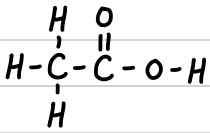
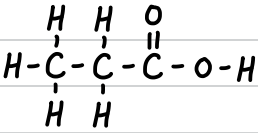
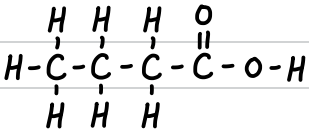
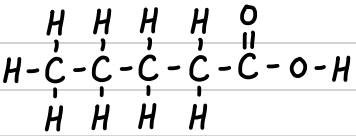
Summary

Answers

Alkanes

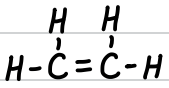
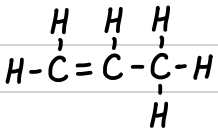
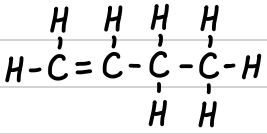
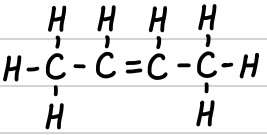
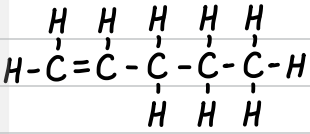
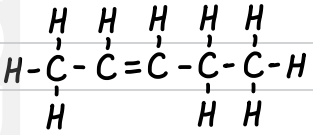
number of C	name	chemical formula	structural formula
1	methane	CH_4	
2	ethane	C_2H_6	
3	propane	C_3H_8	
4	butane	C_4H_{10}	
5	pentane	C_5H_{12}	

Carboxylic acids

number of C	name	chemical formula	structural formula
1	methanoic acid	$HCOOH$	
2	ethanoic acid	CH_3COOH	
3	propanoic acid	C_2H_5COOH	
4	butanoic acid	C_3H_7COOH	
5	pentanoic acid	C_4H_9COOH	

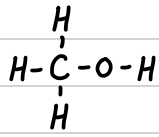
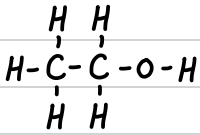
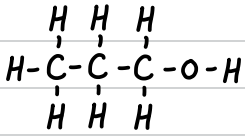
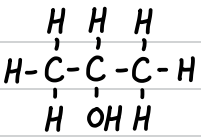
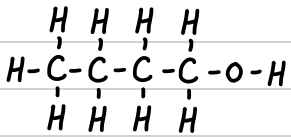
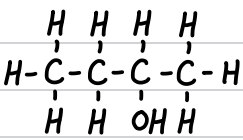
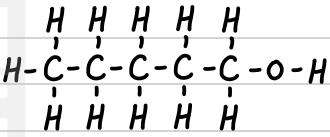
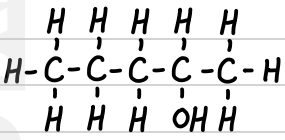
Summary
Answers

Alkenes

number of C	name	chemical formula	structural formula
2	ethene	C_2H_4	
3	propene	C_3H_6	
4	but-1-ene	C_4H_8	
4	but-2-ene	C_4H_8	
5	pent-1-ene	C_5H_{10}	
5	pent-2-ene	C_5H_{10}	

Summary
Answers

Alcohols

number of C	name	chemical formula	structural formula
1	methanol	CH_3OH	
2	ethanol	C_2H_5OH	
3	propan-1-ol	C_3H_7OH	
3	propan-2-ol	C_3H_7OH	
4	butan-1-ol	C_4H_9OH	
4	butan-2-ol	C_4H_9OH	
5	pentan-1-ol	$C_5H_{11}OH$	
5	pentan-2-ol	$C_5H_{11}OH$	
5	pentan-3-ol	$C_5H_{11}OH$