CHEM110 – Chapter 2
The Language of Chemistry

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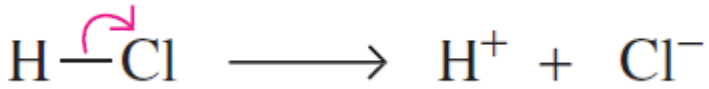
2.2 THREE-DIMENSIONAL STRUCTURES

- In addition to representing structures → also need to depict way chemical bonds break or form

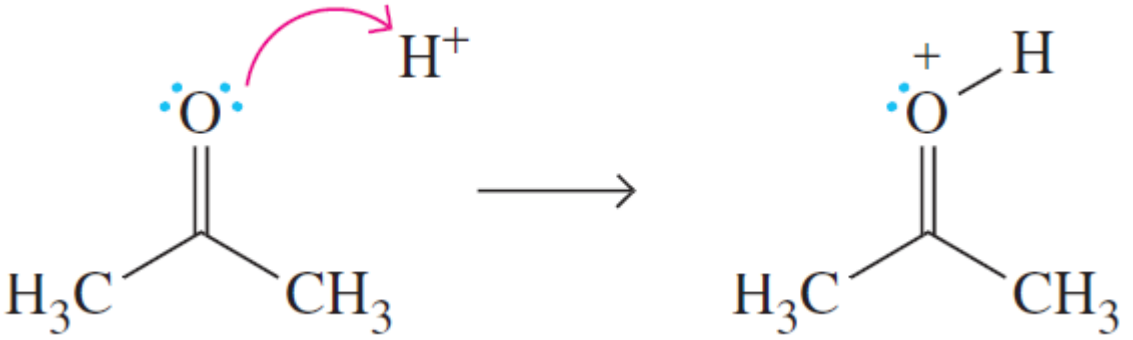
- Use MECHANISTIC ARROWS

2.2 THREE-DIMENSIONAL STRUCTURES

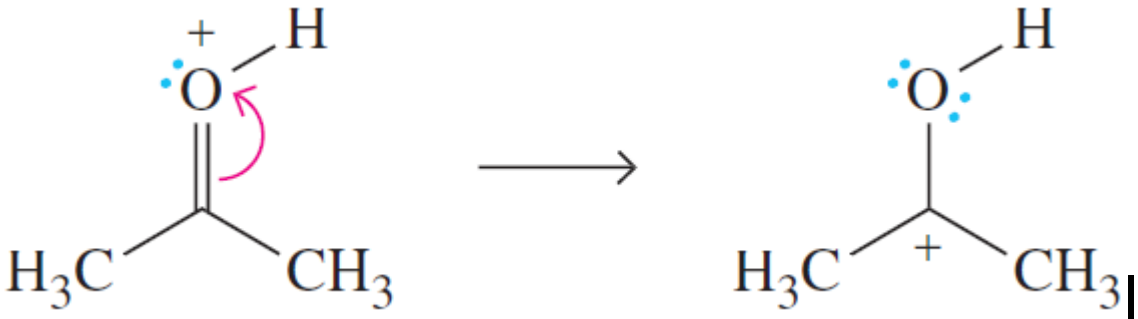
- **Bond breaking**



- **Bond making**



- **Charge neutralisation**



2.3 NOMENCLATURE

- Systematic naming of compounds
- International Union of Pure and Applied Chemistry (IUPAC)
- Common unsystematic names rather than systematic IUPAC name
  - The systematic name of water is oxidane
  - Only a small number of common compound names are accepted by IUPAC

2.3 NOMENCLATURE: INORGANIC COMPOUNDS

1. **The element closer to the left of the periodic table appears first**

2. **First element retains its elemental name.**

3. **The second element is named with the suffix *–ide***

4. **A prefix specifying the number of atoms present is included when > 1 atom**

2.3 NOMENCLATURE: INORGANIC COMPOUNDS

TABLE 2.4 Common roots for naming compounds.

Element	Full name	Root
As	arsenic	arsen-
Br	bromine	brom-
C	carbon	carb-
Cl	chlorine	chlor-
F	fluorine	fluor-
H	hydrogen	hydr-
I	iodine	iod-
N	nitrogen	nitr-
O	oxygen	ox-
P	phosphorus	phosph-
S	sulfur	sulf-

2.3 NOMENCLATURE: INORGANIC COMPOUNDS

TABLE 2.5 Number prefixes for chemical names.

Number	Prefix	Example	Name
1	mono-	CO	carbon monoxide[(a)]
2	di-	SiO_2	silicon dioxide
3	tri-	NI_3	nitrogen triiodide
4	tetra-	$SnCl_4$	tin tetrachloride
5	penta-	PCl_5	phosphorus pentachloride
6	hexa-	SF_6	sulfur hexafluoride
7	hepta-	IF_7	iodine heptafluoride

(a) The final 'o' of the prefix is omitted in this case.

Worked Example 2.9 – page 49

Name the following binary compounds:

SO_2, CS_2, BCl_3, BrF_5, N_2O_5

2.3 NOMENCLATURE: INORGANIC COMPOUNDS

- **Hydrogen requires special consideration**
  - **With elements from group 1 and 17**
    - **GROUP 1 - Lithium hydride LiH**
    - **GROUP 17 - Hydrogen fluoride HF**
  - **With elements from groups 2 and 16, except oxygen**
    - **GROUP 2 - Calcium hydride CaH_2**
    - **GROUP 16 - Hydrogen sulfide H_2S**
  - **Groups 13, 14 and 15**
    - **Unsystematic names e.g. B_2H_6 diborane**

2.3 NOMENCLATURE: IONIC COMPOUNDS

- **Binary (containing 2) ionic compounds are written with the cation first and then the anion, which takes the suffix –*ide*, last**
  - **Potassium iodide** **KI**
  - **Calcium fluoride** **CaF_2**

- **Ionic compounds may contain polyatomic ions**
  - **Ammonium** **NH_4^+**
  - **Nitrate** **NO_3^-**

2.3 NOMENCLATURE: OXOANIONS

1. **The root name arises from the central atom**
   - **e.g. carbonate CO_3^{2-}**

2. **When an element forms 2 different oxoanions, the one with fewer oxygen atoms ends in *–ite*, the one with more oxygens ends in *–ate***
   - **Sulfite SO_3^{2-}**
   - **Sulfate SO_4^{2-}**

2.3 NOMENCLATURE: OXOANIONS

3. **Four oxoanions for chlorine, bromine and iodine. Distinguished by prefixes and suffixes -**
   - **Hypobromite BrO^-**
   - **Bromite BrO_2^-**
   - **Bromate BrO_3^-**
   - **Perbromate BrO_4^-**

4. **A polyatomic anion with a charge more negative than 1- may add H^+ to give another anion. Named from the parent anion by adding the word hydrogen**
   - **Hydrogen phosphate HPO_4^{2-}**
   - **Dihydrogen phosphate $H_2PO_4^-$**

2.3 NOMENCLATURE: ORGANIC COMPOUNDS

- Composed primarily of carbon and hydrogen atoms

- Naming system based on number of carbons in the main part of the molecule → parent molecule

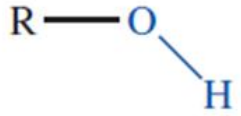
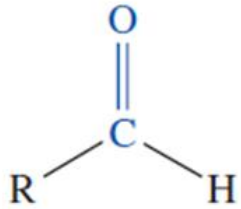
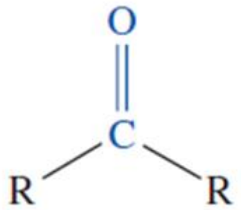
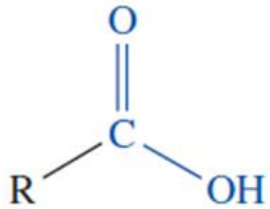
- Start with FUNCTIONAL GROUPS

2.3 NOMENCLATURE: ORGANIC COMPOUNDS

- **FUNCTIONAL GROUPS**
  - A group of one or more atoms within a molecule, bonded together in a particular way
  - Usually the point of reaction within a molecule
  - Organic molecules are named according to functional groups (as well as the parent)
  - Molecules containing same functional group tend to behave in chemically similar ways

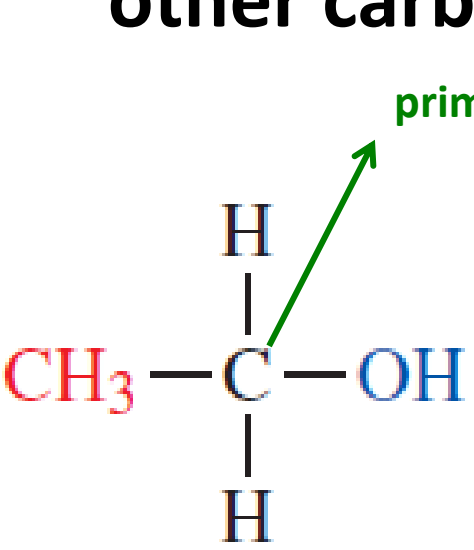
2.3 NOMENCLATURE: ORGANIC COMPOUNDS

Table 2.7

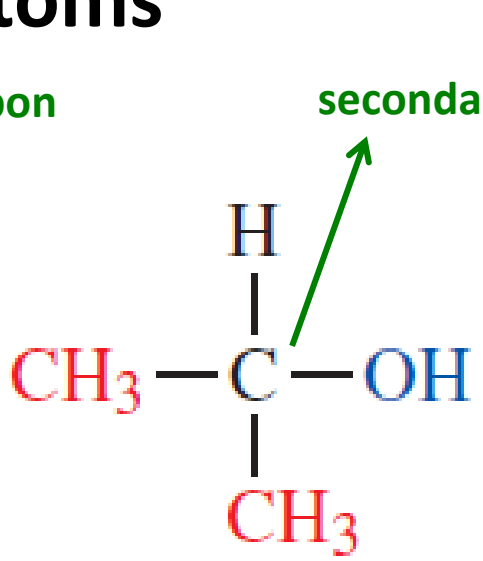
Functional group	Name of group	Found in	R =
	hydroxyl	alcohols	C
	carbonyl	aldehydes	C or H
	carbonyl	ketones	C
	carboxyl	carboxylic acids	C or H

2.3 NOMENCLATURE: ALCOHOLS

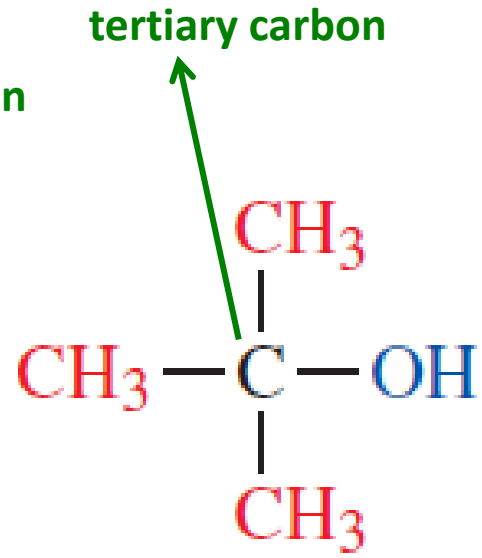
- **Hydroxyl (-OH) functional group attached to other carbon atoms**



primary alcohol



secondary alcohol



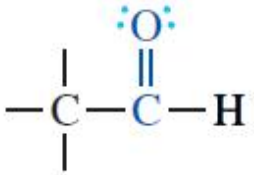
tertiary alcohol

Worked Example 2.10 – page 51

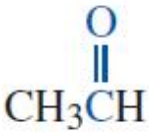
Write condensed structural formulae for the two alcohols with the molecular formula C_3H_8O. Classify each as primary, secondary or tertiary.

2.3 NOMENCLATURE: CARBONYL GROUPS

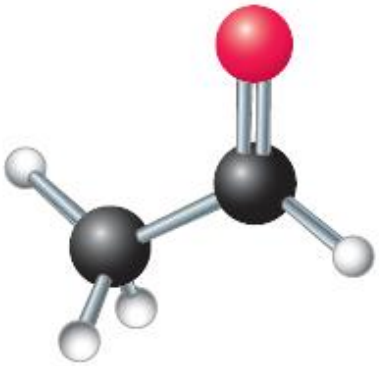
- **Carbonyl (C=O) functional group**

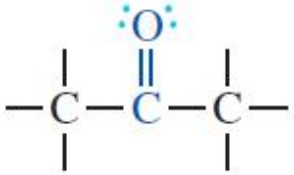


functional group

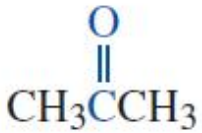


aldehyde

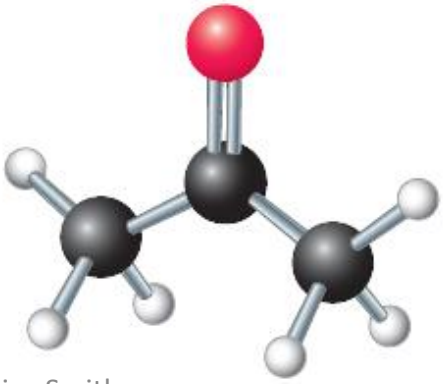




functional group



ketone

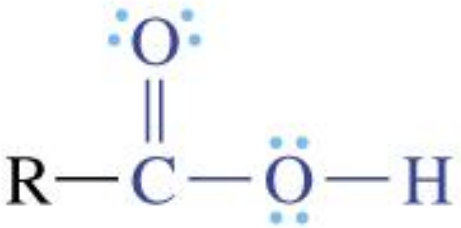


Worked Example 2.11 – page 52

Write condensed structural formulae for the two aldehydes with the chemical formula C_4H_8O.

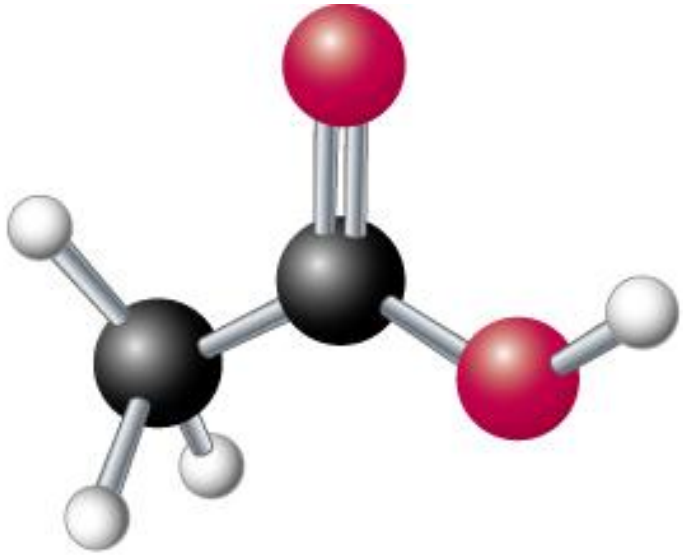
2.3 NOMENCLATURE: CARBOXYLIC ACIDS

- **Carboxyl group → –COOH**



functional group

acetic acid



Worked Example 2.12 – page 53

Write condensed structural formulae for the carboxylic acid with the molecular formula $C_3H_6O_2$.

2.3 NOMENCLATURE: ALKANES

- Contain only CARBON and HYDROGEN and only SINGLE BONDS between the carbons
  - C_nH_{2n+2} → Acyclic alkanes (carbons joined in chains)
  - C_nH_{2n} → Cycloalkanes (carbons joined in rings)
- Sometimes called SATURATED HYDROCARBONS → all the carbon-carbon bonds are single
- Two parts to the name
  - Prefix → # carbons in the chain
  - Ending → "-ane" indicating an alkane

2.3 NOMENCLATURE: ALKANES

Prefix	Number of carbon atoms
meth-	1
eth-	2
prop-	3
but-	4
pent-	5
hex-	6
hept-	7
oct-	8
non-	9
dec-	10

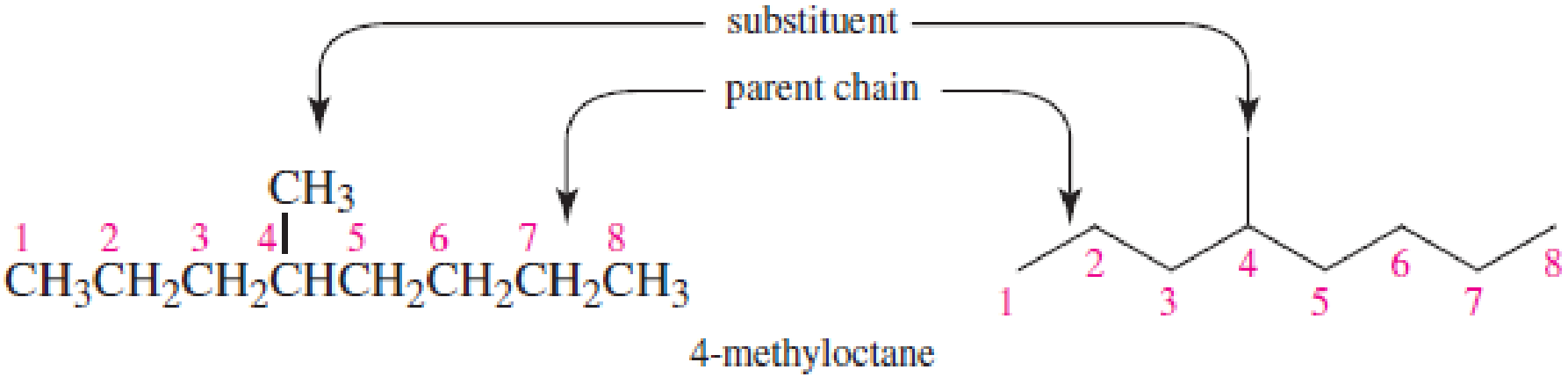
Table 2.8

2.3 NOMENCLATURE: ALKANES

1. Name for alkane with unbranched chain of carbon atoms consists of a prefix showing the number of carbon atoms in the chain, and the ending –ane
2. For branched-chain alkanes → the longest chain of carbon atoms is the parent chain and its name is the root name

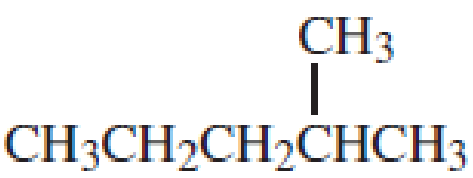
2.3 NOMENCLATURE: ALKANES

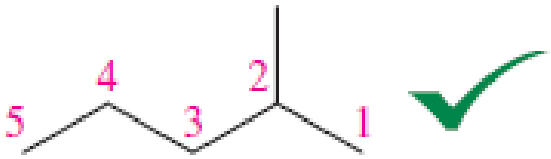
- **Parent chain**: the **longest** carbon chain
- **Substituents**: any branch off the parent chain

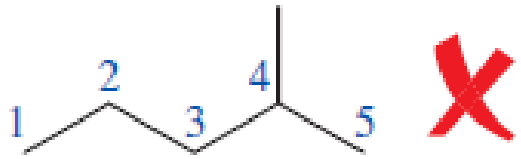


2.3 NOMENCLATURE: ALKANES

3. One substituent → number the parent chain so that the carbon atom bearing the substituent is given the lowest possible number

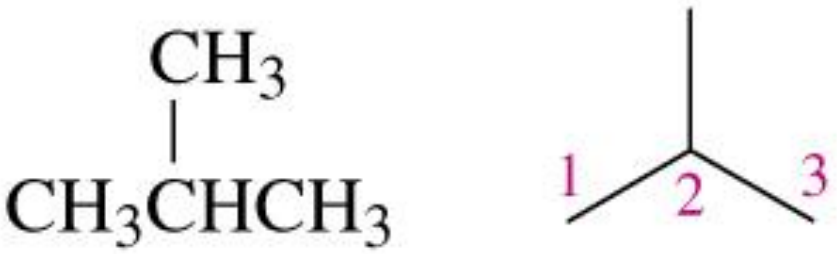






2.3 NOMENCLATURE: ALKANES

4. Give the substituent on the parent chain a name and a number. The number shows the carbon atom of the parent chain to which the substituent is bonded. Use a hyphen to connect the number to the name.



2-methylpropane

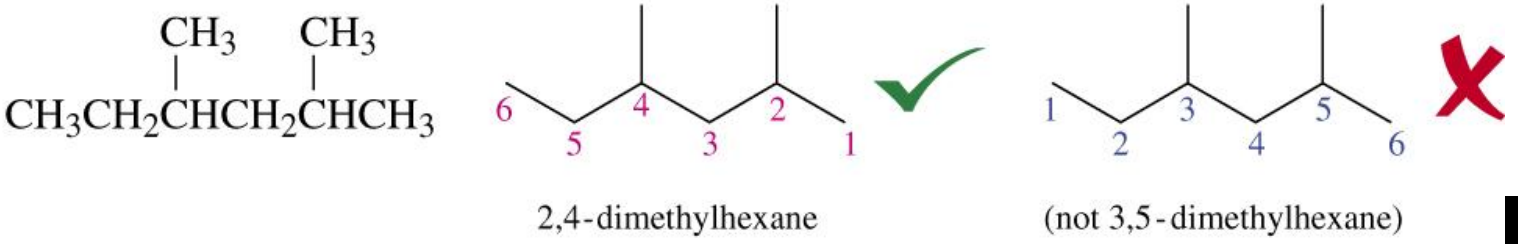
2.3 NOMENCLATURE: ALKANES

TABLE 2.9 Names, formulae and abbreviations of the most common alkyl groups.

Name	Condensed structural formula	Abbreviation
methyl	$-CH_3$	Me
ethyl	$-CH_2CH_3$	Et
propyl	$-CH_2CH_2CH_3$	Pr
isopropyl	$-CH(CH_3)_2$	i-Pr
butyl	$-CH_2CH_2CH_2CH_3$	Bu
isobutyl	$-CH_2CH(CH_3)_2$	i-Bu
sec-butyl	$-CH(CH_3)CH_2CH_3$	*s*-Bu
tert-butyl	$-C(CH_3)_3$	*t*-Bu

2.3 NOMENCLATURE: ALKANES

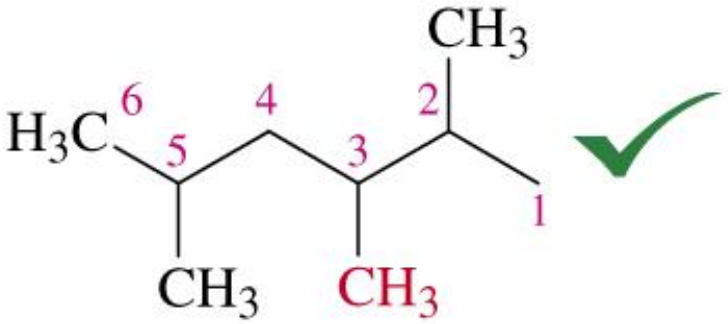
5. If two or more identical substituents, number the parent chain from the end that gives the lowest numbers to the substituents. The number of times the substituent occurs is indicated by the prefixes *di-*, *tri-*, *tetra-*, *penta-*, *hexa-*, and so on.



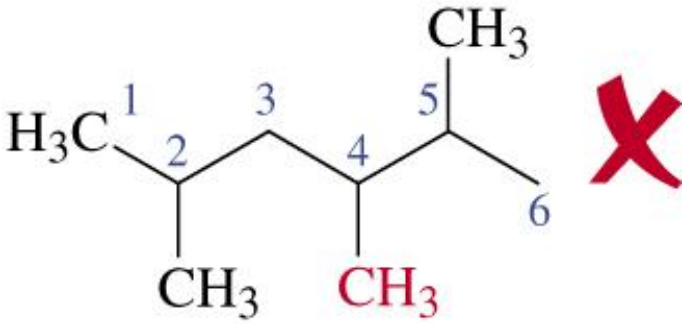
2,4-dimethylhexane (not 3,5-dimethylhexane)

2.3 NOMENCLATURE: ALKANES

6. If step 5 leads to more than one possibility, number the parent chain such that the first point of difference has the lowest possible number.



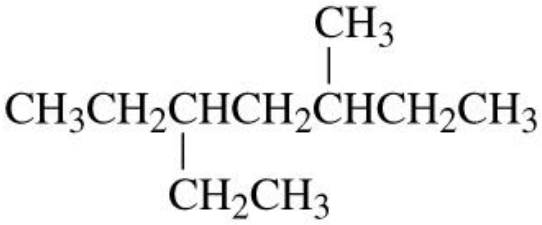
2,3,5-trimethylhexane

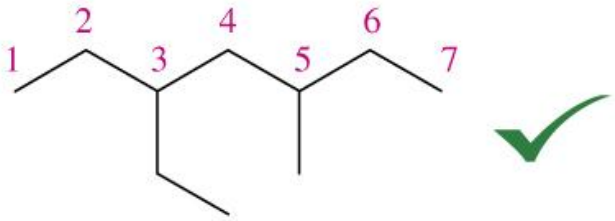


(not 2,4,5-trimethylhexane)

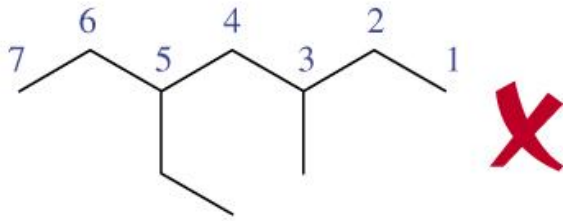
2.3 NOMENCLATURE: ALKANES

7. If there are two or more substituents list them in alphabetical order. If there are different substituents in equivalent positions on opposite ends of the parent chain, the substituent of lower alphabetical order is given the lower number.





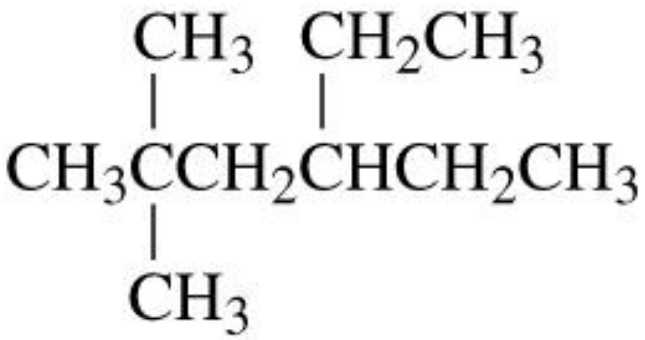
3-ethyl-5-methylheptane

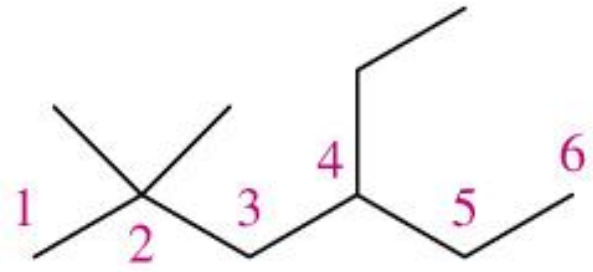


(not 3-methyl-5-ethylheptane)

2.3 NOMENCLATURE: ALKANES

8. The prefixes *di-*, *tri-*, and hyphenated prefixes such as *sec-* and *tert-* are disregarded for the purposes of alphabetical ordering.

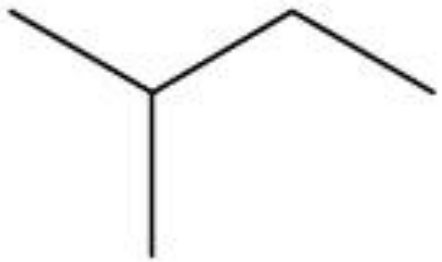


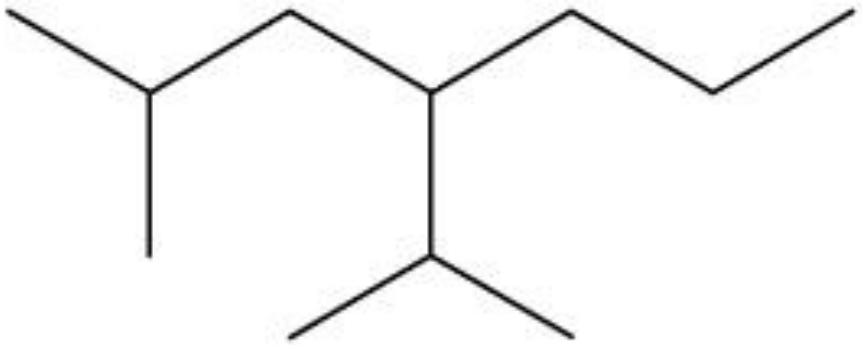


4-ethyl-2,2-dimethylhexane
(not 2,2-dimethyl-4-ethylhexane)

Worked Example 2.13 – page 56

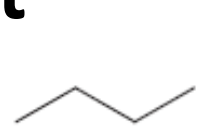
Write IUPAC names for the following alkanes:

(a) 

(b) 

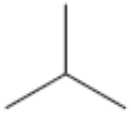
2.3 ISOMERISATION: ALKANES

- **Constitutional isomers → compounds with the same chemical formula but different order of attachment**



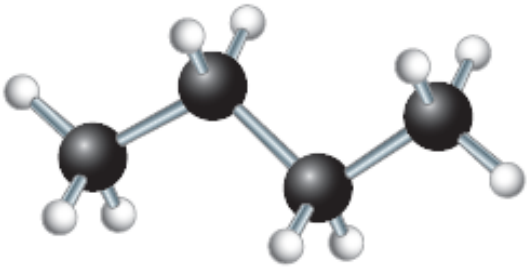
$CH_3CH_2CH_2CH_3$

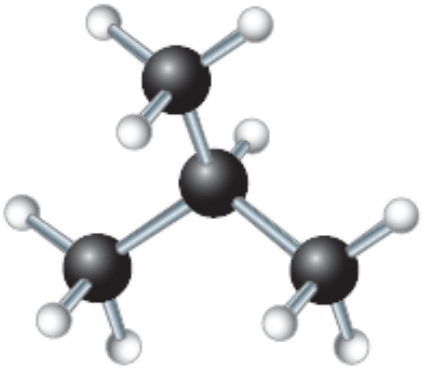
butane
(bp = −0.5 °C)



CH_3CHCH_3
|
CH_3

2-methylpropane
(bp = −11.6 °C)

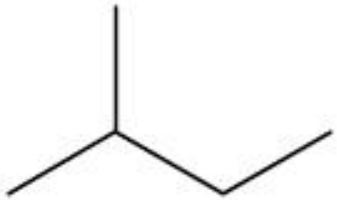




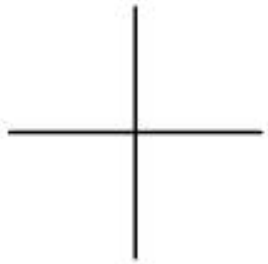
2.3 ISOMERISATION: ALKANES

C_5H_{12}

pentane



2-methylbutane



2,2-dimethylpropane

Worked Example 2.14 – page 58

Do the structural formulae in each of the following pairs of molecules represent the same compound or constitutional isomers?

(a) $CH_3CH_2CH_2CH_2CH_2CH_3$ and $CH_3CH_2CH_2(CH_2CH_2CH_3)$ (each is C_6H_{14})

(b) $CH_3CHCH_2CH(CH_3)CH_3$ and $CH_3CH_2CH(CH_3)CHCH_3$ (each is C_7H_{16})

Worked Example 2.15 – page 59

Draw the structural formulae for the five constitutional isomers with the molecular formula C_6H_{14}.

GENERAL ORGANIC NOMENCLATURE

- **Page 59-60**
- **Please go over yourselves**
- **Practice Exercise 2.19 and Review Exercise 2.8**

LEARNING OBJECTIVES

- Understand measurement and units relevant to studies in chemistry
- Learn different representations for molecules
- Be able to name chemical species using conventional chemical nomenclature

Ch 2 – Wrap up

- Summary – pg 61
- Key Concepts and Equations – pg 62
- Key Terms – pg 63
- Review Questions – pg 63
- Review Problems – pg 64
- Additional Problems – pg 68