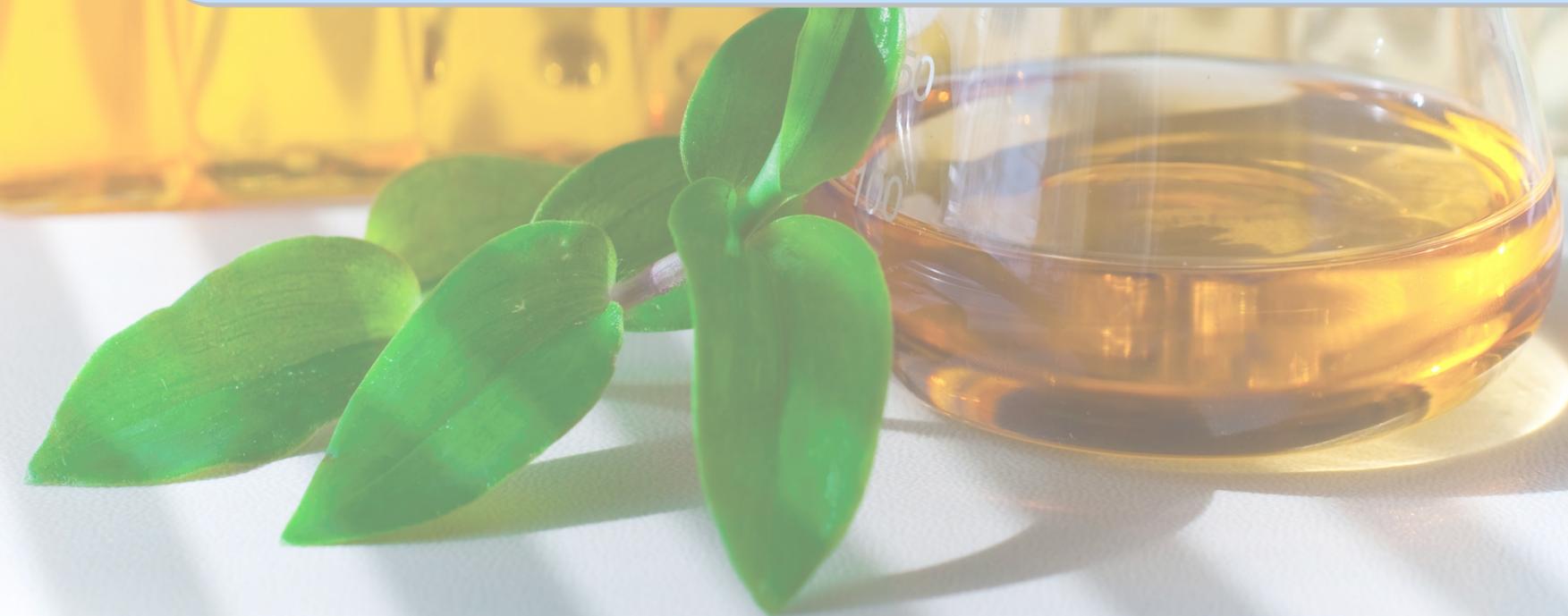


Topic 7 Fossil Fuels and Carbon Compounds

Unit 26 Homologous series, structural formulae and naming of carbon compounds





Content

- ➔ 26.1 Chemistry of carbon compounds
- ➔ 26.2 Formulae of carbon compounds
- ➔ 26.3 Functional groups and homologous series
- ➔ 26.4 Homologous series of alkanes
- ➔ 26.5 Naming alkanes
- ➔ 26.6 Writing structural formulae from systematic names

Continued on next page ➔



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- ➔ 26.7 Naming alkenes
- ➔ 26.8 Naming alkanols
- ➔ 26.9 Naming alkanolic acids
- ➔ 26.10 Physical properties of alkanes
- ➔ Key terms
- ➔ Summary
- ➔ Unit Exercise



26.1 Chemistry of carbon compounds (p.51)

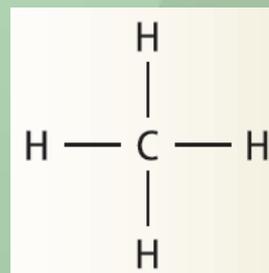
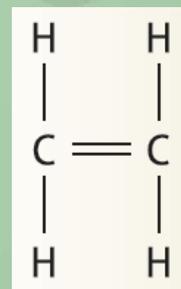
- ◆ Carbon compounds make up body cells, food, clothes, synthetic polymers, etc.
- ◆ Also called 'organic compounds' because early chemists thought that such compounds were only made by living things





26.1 Chemistry of carbon compounds (p.51)

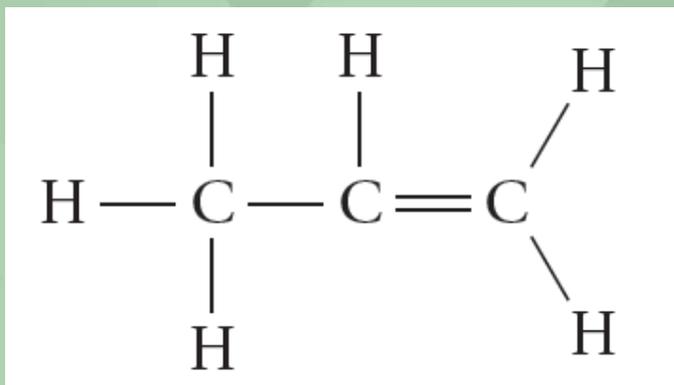
- ◆ Number of carbon-containing compounds (over ten million) > number of compounds of all the other elements put together
- ◆ Reasons:
 - ability to form straight or branched carbon chains and rings;
 - C–C and C–H bonds are strong with low polarities;
 - form single or multiple bonds (C has 4 outermost shell e⁻);
 - e⁻ other than those in C–C bonds can form bonds with other elements such as H, O and halogens.





26.2 Formulae of carbon compounds (p.53)

- ◆ Empirical formula (e.g. CH_2)—simplest whole number ratio of atoms
- ◆ Molecular formula (e.g. C_3H_6)—total number of each element
- ◆ **Structural formula (結構式)**—how atoms are linked together



Structural formula of propene

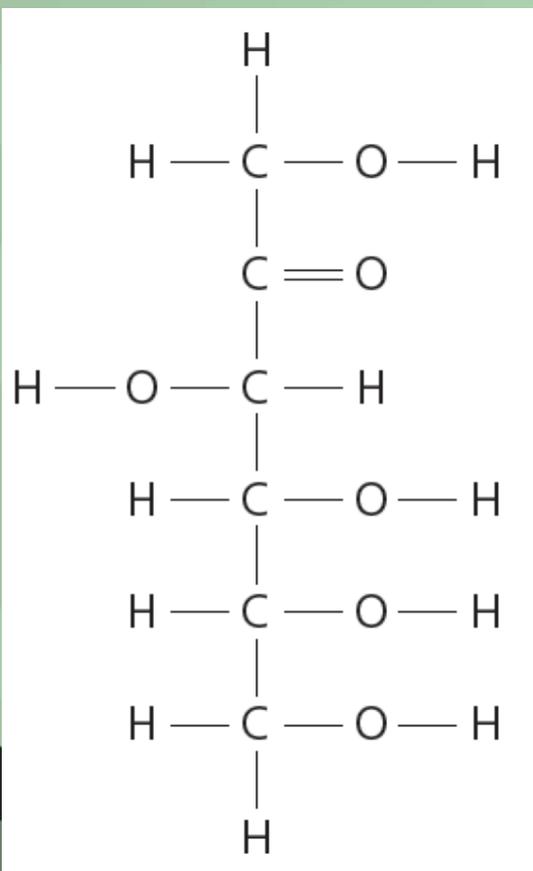


26.2 Formulae of carbon compounds (p.53)

Practice 26.1

The structure of fructose is shown below.

What are the molecular and empirical formulae of fructose?



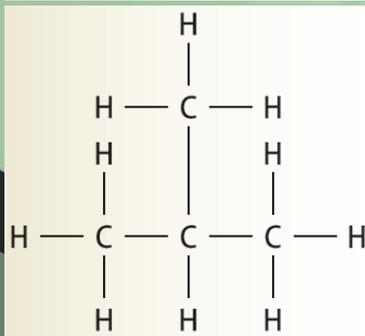
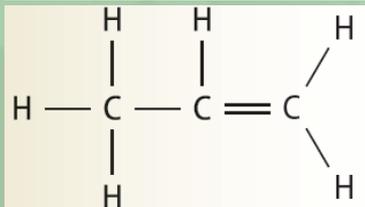
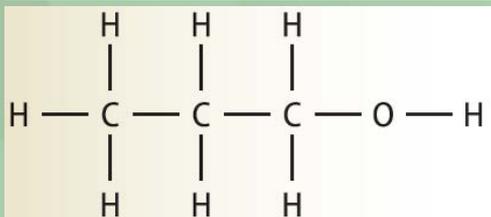
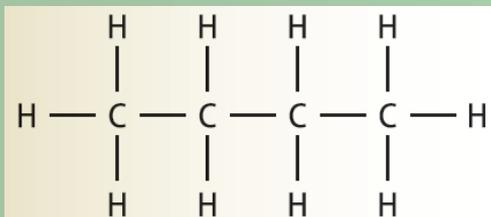
Molecular formula: $\text{C}_6\text{H}_{12}\text{O}_6$
Empirical formula: CH_2O



26.2 Formulae of carbon compounds (p.53)

- ◆ **Condensed structural formula (簡明結構式)**—in simplified form

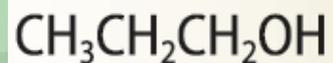
Structural formula



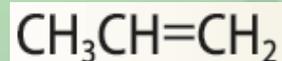
Condensed structural formula



showing repetition



showing a group



showing all multiple bonds



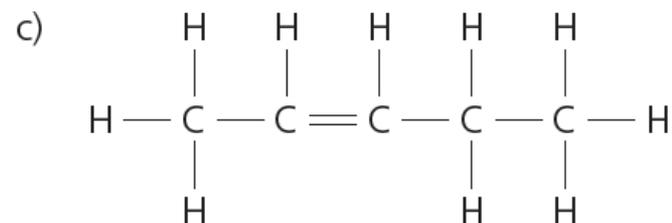
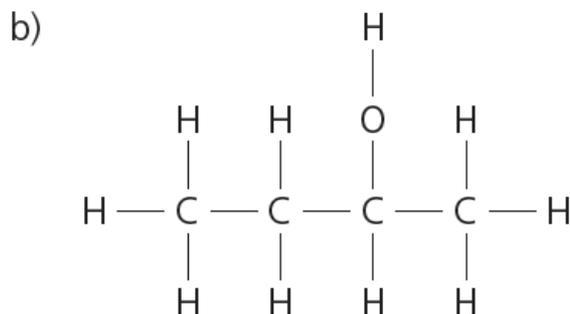
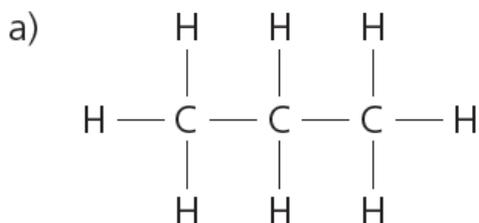
showing branched chains



26.2 Formulae of carbon compounds (p.53)

Practice 26.2

What are the condensed structural formulae of the following compounds?

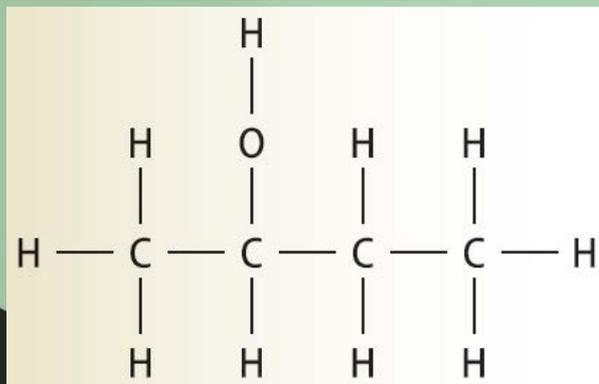
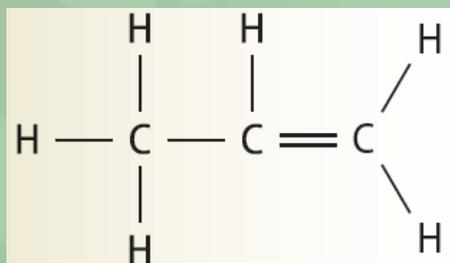
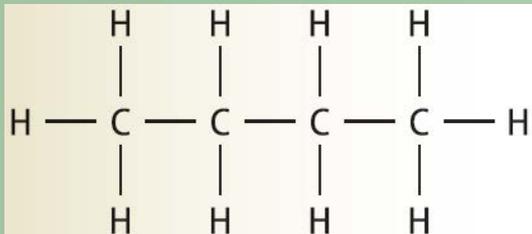




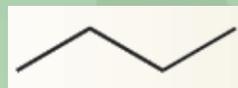
26.2 Formulae of carbon compounds (p.53)

- ◆ **Skeletal formula (骨架式)**—C not written out ; H on C omitted

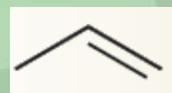
Structural formula



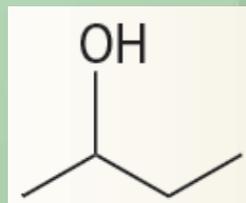
Skeletal formula



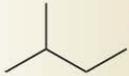
C at every end or turn



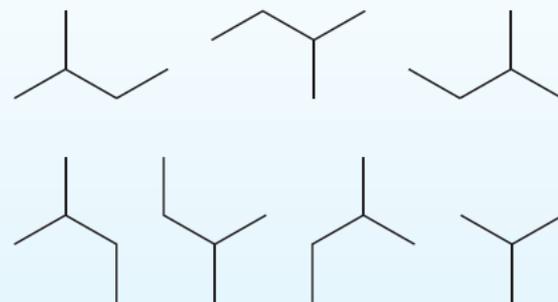
showing multiple bonds



showing H not attached to C

Structural formula	Condensed structural formula	Skeletal formula
$ \begin{array}{ccccccccc} & \text{H} & & \text{H} & & \text{H} & & \text{H} & & \text{H} \\ & & & & & & & & & \\ \text{H} & - \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - \text{H} \\ & & & & & & & & & \\ & \text{H} & & \text{H} & & \text{H} & & \text{H} & & \text{H} \end{array} $	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$ or $\text{CH}_3(\text{CH}_2)_3\text{CH}_3$	
$ \begin{array}{ccccccc} & & & \text{H} & & & \\ & & & & & & \\ & \text{H} & - & \text{C} & - & \text{H} & \\ & & & & & & \\ & \text{H} & & & & \text{H} & & \text{H} \\ & & & & & & & \\ \text{H} & - \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - \text{H} \\ & & & & & & & \\ & \text{H} & & \text{H} & & \text{H} & & \text{H} \end{array} $	$(\text{CH}_3)_2\text{CHCH}_2\text{CH}_3$ or $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)_2$	
$ \begin{array}{ccccccc} & & & \text{H} & & & \\ & & & & & & \\ & \text{H} & - & \text{C} & - & \text{H} & \\ & & & & & & \\ & \text{H} & & & & \text{H} & & \text{H} \\ & & & & & & & \\ \text{H} & - \text{C} & - & \text{C} & - & \text{C} & - & \text{H} \\ & & & & & & & \\ & \text{H} & & & & \text{H} & & \text{H} \\ & & & \text{H} & & & & \text{H} \\ & & & & & & & \\ & & & \text{H} & & & & \end{array} $	$\text{C}(\text{CH}_3)_4$	

▶ The following skeletal formulae may look different, but they are just the same formula rotated or flipped in different ways.





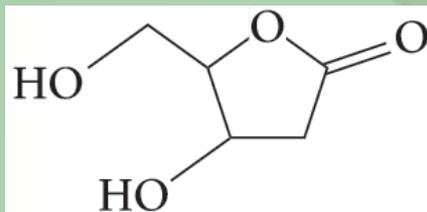
Structural formula	Condensed structural formula	Skeletal formula



26.2 Formulae of carbon compounds (p.53)

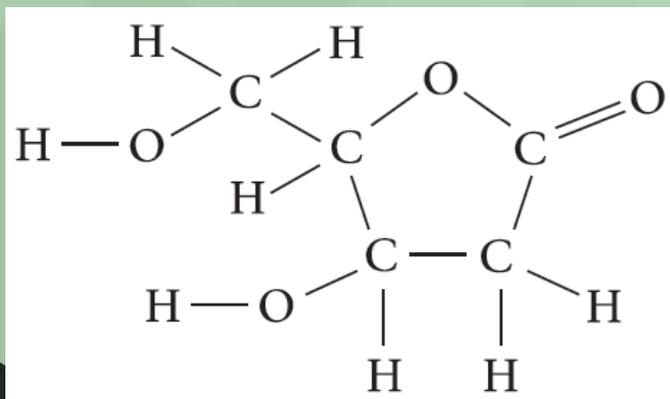
Q (Example 26.2)

Work out the structural and molecular formulae of this compound:



A

The structural formula of the compound is shown below.



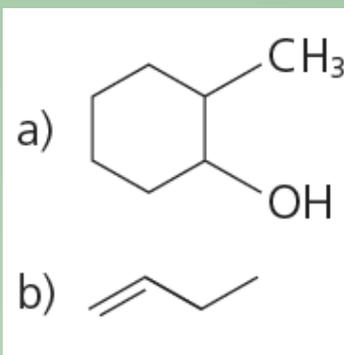
The molecular formula the compound is $C_5H_8O_4$.



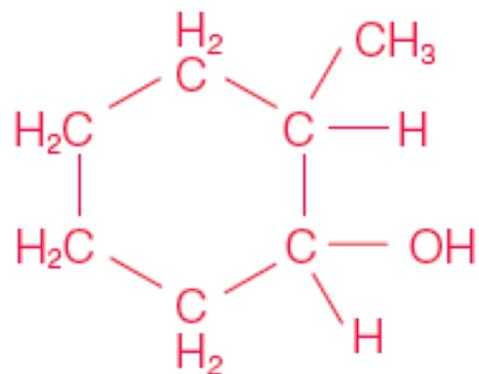
26.2 Formulae of carbon compounds (p.53)

Practice 26.3

1 What are the molecular formulae of the following compounds?

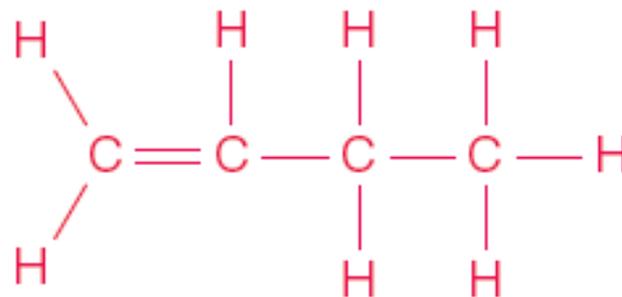


a) The structural formula of the compound is shown below.



The molecular formula of the compound is $C_7H_{14}O$.

b) The structural formula of the compound is shown below.



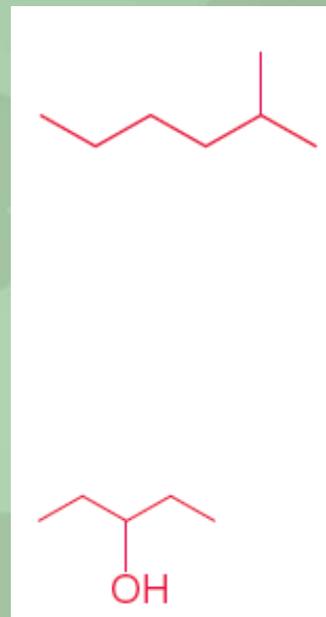
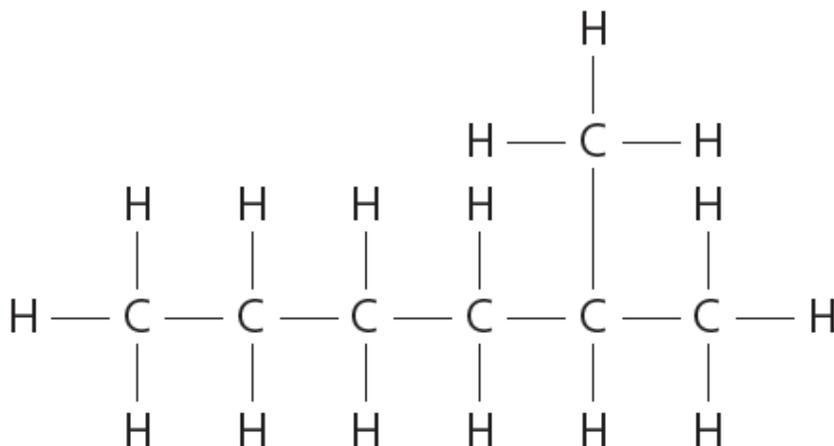
The molecular formula of the compound is C_4H_8 .



26.2 Formulae of carbon compounds (p.53)

2 Write the skeletal formulae of the following compounds.

a)





26.3 Functional groups and homologous series (p.60)

- The $-O-H$ group, called **hydroxyl group** (羟基), in ethanol has a significant effect on its properties.

▶ **Table 26.6** A comparison of the physical and chemical properties of ethane, ethanol and propan-1-ol

Physical / chemical property	Ethane	Ethanol	Propan-1-ol
Melting point ($^{\circ}C$)	-183	-114	-126
Boiling point ($^{\circ}C$)	-89	78	97
State at room temperature	gas	liquid	liquid
Solubility in water	insoluble	soluble	soluble
Reaction with sodium	no reaction	$H_2(g)$ evolved	$H_2(g)$ evolved

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26.3 Functional groups and homologous series (p.60)

Ethanol's b.p. is almost 170°C higher than that of ethane.

Ethanol is completely soluble in water while ethane is insoluble.

Ethanol reacts with sodium while ethane does not.

- ◆ A **functional group** (官能基) is either a single atom or group of atoms which determines most of the properties of a compound.
- ◆ All compounds containing the same functional group have similar chemical properties.
- ◆ Their physical properties are similar but vary much depending on the length of the carbon chain attached to the functional group.



Table 26.7 Functional groups and names of some homologous series

Functional group		Name of homologous series	Example
Formula	Name		
$C = C$	carbon-carbon double bond	alkene	$ \begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad / \\ \text{H} - \text{C} - \text{C} = \text{C} \\ \quad \quad \backslash \\ \text{H} \quad \quad \text{H} \end{array} $
$— O — H$	hydroxyl group	alkanol	$ \begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \\ \text{H} - \text{C} - \text{C} - \text{C} - \text{O} - \text{H} \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \end{array} $
$ \begin{array}{c} \text{O} \\ // \\ - \text{C} \\ \backslash \\ \text{O} - \text{H} \end{array} $	carboxyl group	alkanoic acid	$ \begin{array}{c} \text{H} \quad \text{H} \quad \text{O} \\ \quad \quad // \\ \text{H} - \text{C} - \text{C} - \text{C} \\ \quad \quad \backslash \\ \text{H} \quad \text{H} \quad \text{O} - \text{H} \end{array} $



26.3 Functional groups and homologous series (p.60)

Q (Example 26.3)

Compound X contains carbon, hydrogen and oxygen only. The relative molecular mass of X is 88.0. Completer combustion of 1.98 g of X gives 3.96 g of carbon dioxide and 1.62 g of water.

- Deduce the molecular formula of X.
(Relative atomic masses: H = 1.0, C = 12.0, O = 16.0)
- Given that X has only one functional group, write TWO possible structural formulae of X.



26.3 Functional groups and homologous series (p.60)

A

a)

$$\begin{aligned} \text{C} \quad & 3.96 \text{ g CO}_2 \times \frac{12.0 \text{ g C}}{44.0 \text{ g CO}_2} \\ & = 1.08 \text{ g} \end{aligned}$$

$$\frac{1.08 \text{ g}}{12.0 \text{ g mol}^{-1}} = 0.0900 \text{ mol}$$

$$\frac{0.0900 \text{ mol}}{0.0450 \text{ mol}} = 2$$

$$\begin{aligned} \text{H} \quad & 1.62 \text{ g H}_2\text{O} \times \frac{2.00 \text{ g H}}{18.0 \text{ g H}_2\text{O}} \\ & = 0.180 \text{ g} \end{aligned}$$

$$\frac{0.180 \text{ g}}{1.0 \text{ g mol}^{-1}} = 0.180 \text{ mol}$$

$$\frac{0.180 \text{ mol}}{0.0450 \text{ mol}} = 4$$

$$\begin{aligned} \text{O} \quad & (1.98 - 1.08 - 0.180) \text{ g} \\ & = 0.720 \text{ g} \end{aligned}$$

$$\frac{0.720 \text{ g}}{16.0 \text{ g mol}^{-1}} = 0.0450 \text{ mol}$$

$$\frac{0.0450 \text{ mol}}{0.0450 \text{ mol}} = 1$$

Empirical formula of X is $\text{C}_2\text{H}_4\text{O}$. Its molecular formula is $(\text{C}_2\text{H}_4\text{O})_n$.

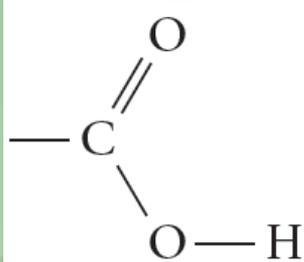
$$88.0 = n(2 \times 12.0 + 4 \times 1.0 + 16.0)$$

$n = 2$; molecular formula:

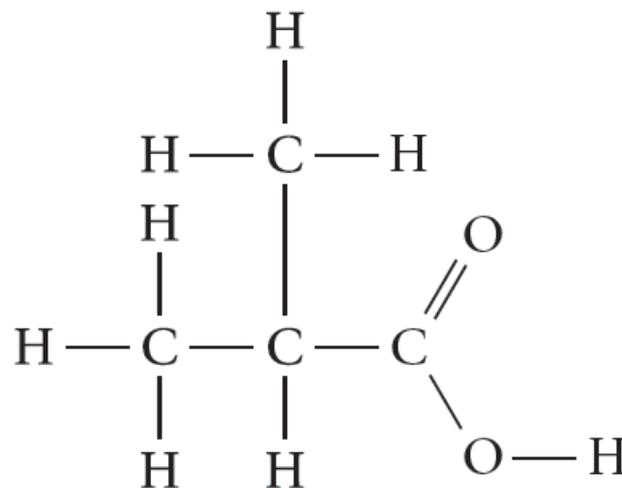
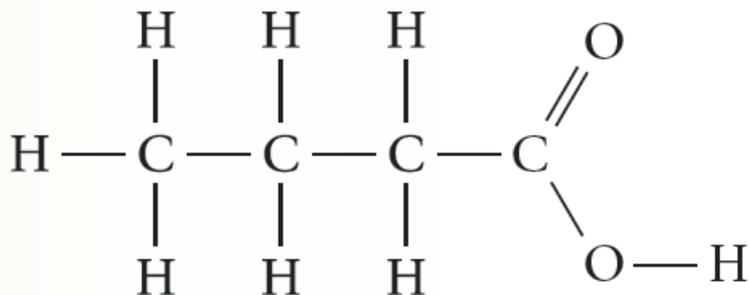




26.3 Functional groups and homologous series (p.60)

b) X probably contains a carboxy group ().

Two possible structural formulae of X are shown below.

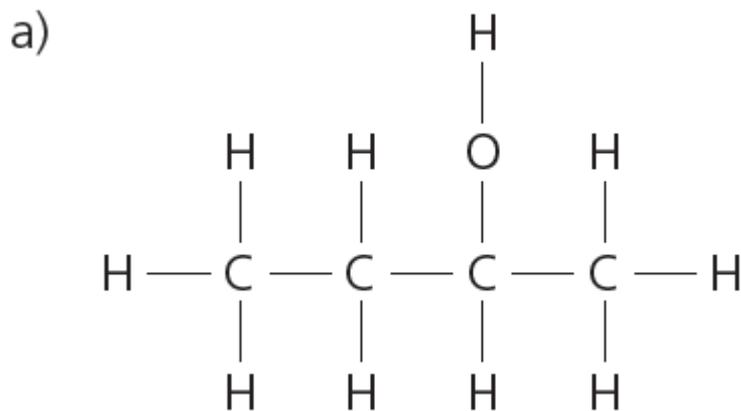




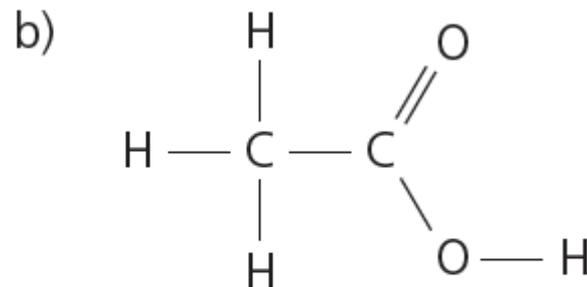
26.3 Functional groups and homologous series (p.60)

Practice 26.4

1 Identify the functional group in each of the following compounds and the homologous series to which each belongs.



Functional group: hydroxyl group
Homologous series: alkanols



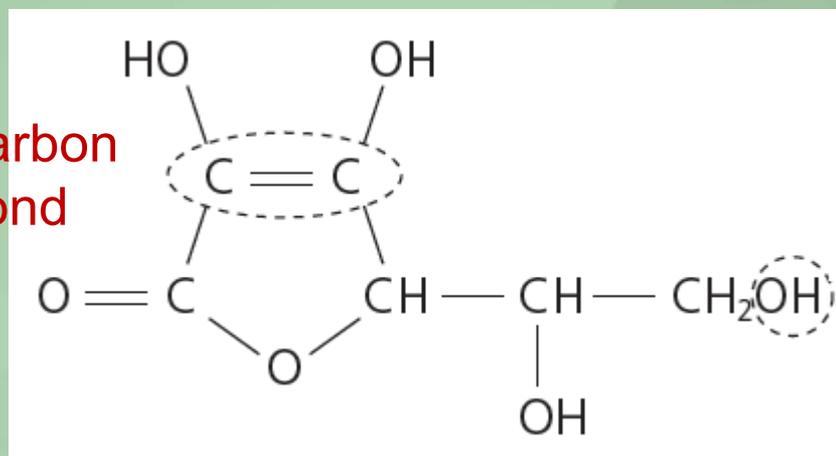
Functional group: carboxyl group
Homologous series: alkanolic acids



26.3 Functional groups and homologous series (p.60)

2 The diagram below shows the structural formula of vitamin C. Identify the functional groups circled.

carbon-carbon
double bond



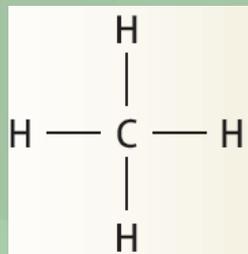
hydroxyl group



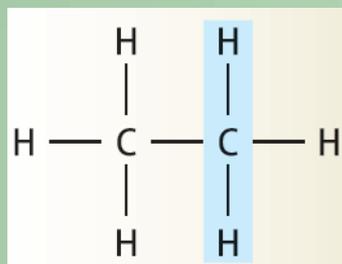
26.4 Homologous series of alkanes (p.64)

- Alkanes—main components of natural gas and petroleum.
- First four alkanes:

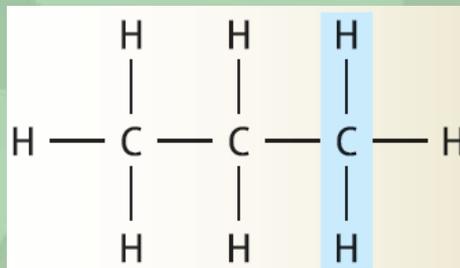
Methane CH_4



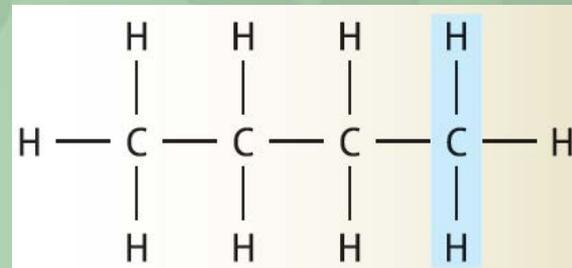
Ethane C_2H_6



Propane C_3H_8



Butane C_4H_{10}

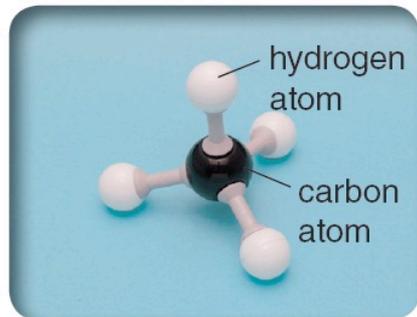


- General formula (通式):** $\text{C}_n\text{H}_{2n+2}$
- Members in a homologous series show:
 - same general formula;
 - each differing from the next by $-\text{CH}_2-$;
 - similar chemical properties;
 - gradual change in physical properties.

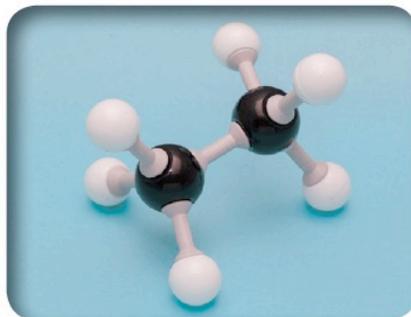


26.4 Homologous series of alkanes (p.64)

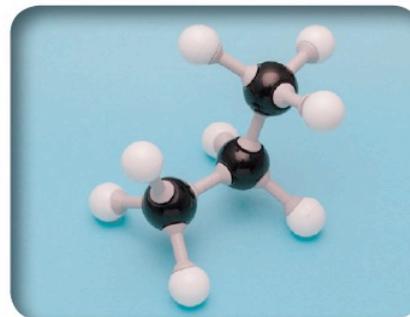
- ◆ In an alkane molecule,
 - each carbon atom is surrounded by four electron pairs;
 - electron pair repulsions result in a tetrahedral arrangement of C



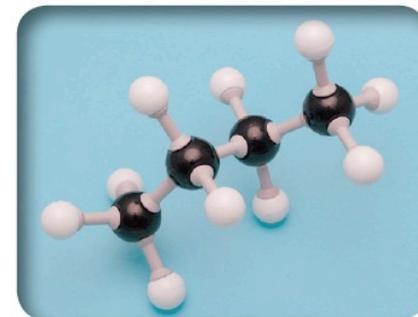
methane



ethane



propane



butane

Ball-and-stick models of the first four straight-chain alkanes



Molecular model [Ref.](#)



Building molecular models of alkanes



26.4 Homologous series of alkanes (p.64)

Practice 26.5

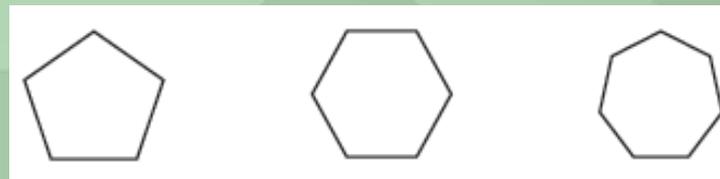
1 Octane is the eighth member of the homologous series of alkanes.

a) Octane has 8 carbon atoms in each of its molecules. What is the molecular formula of octane? C_8H_{18}

b) Name the natural resource from which octane is obtained.

Petroleum

2 The skeletal formulae of three cycloalkanes are shown:



Any two of the following:

- They have the same general formula, i.e. C_nH_{2n} .
- Each member differs from the next by a $-CH_2-$ unit, i.e. C_5H_{10} , C_6H_{12} , C_7H_{14} .
- They have similar chemical properties.
- Their physical properties show a graduation, e.g. the boiling points of the cycloalkanes increase from C_5H_{10} , C_6H_{12} to C_7H_{14} .

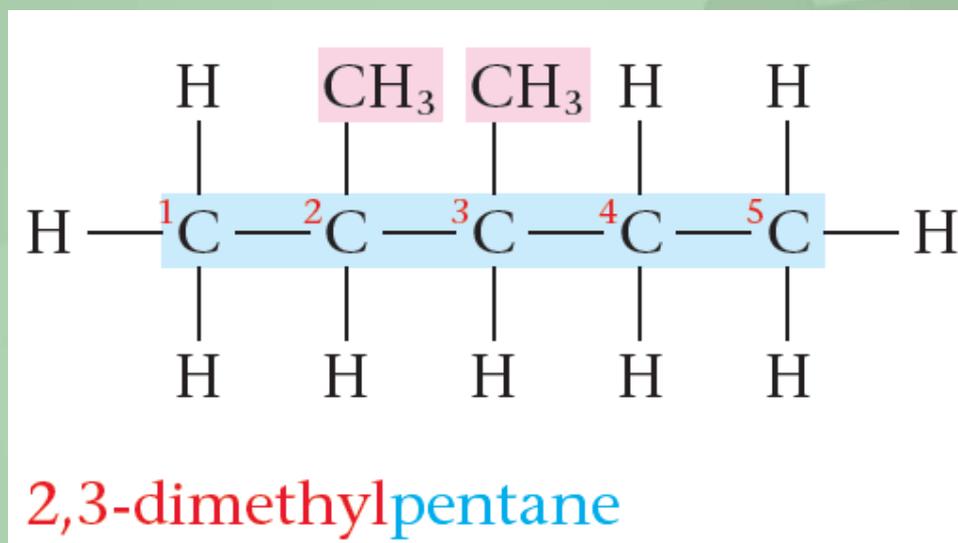
These three cycloalkanes belong to the same homologous series

State TWO characteristics of members of the same homologous series.



26.5 Naming alkanes (p.66)

- ◆ **International Union of Pure and Applied Chemistry (IUPAC)** (國際純粹與應用化學聯合會)—the recognised authority for naming chemical compounds



Prefix (詞首) tells what is attached to the stem.

Suffix (詞尾) tells it's, e.g., an alkane

Stem (詞幹) tells the number of carbon atoms in the parent chain



26.5 Naming alkanes (p.66)

Table 26.9 Patterns of the systematic names of the first eight straight-chain alkanes

Number of carbon atoms per molecule	Structural formula	Stem name	Systematic name
1	$ \begin{array}{c} \text{H} \\ \\ \text{H} - \text{C} - \text{H} \\ \\ \text{H} \end{array} $	meth- meth-	methane methane
2	$ \begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H} - \text{C} - \text{C} - \text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array} $	eth- eth-	ethane ethane
3	$ \begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \\ \text{H} - \text{C} - \text{C} - \text{C} - \text{H} \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \end{array} $	prop- prop-	propane propane
4	$ \begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \\ \text{H} - \text{C} - \text{C} - \text{C} - \text{C} - \text{H} \\ \quad \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array} $	but- but-	butane butane



26.5 Naming alkanes (p.66)

<p>5</p> <p>5</p>	$ \begin{array}{cccccc} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\ & & & & & \\ \text{H} & - \text{C} & - \text{H} \\ & & & & & \\ & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array} $	<p>pent-</p> <p>pent-</p>	<p>pentane</p> <p>pentane</p>
<p>6</p> <p>6</p>	$ \begin{array}{cccccc} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\ & & & & & & \\ \text{H} & - \text{C} & - \text{H} \\ & & & & & & \\ & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array} $	<p>hex-</p> <p>hex-</p>	<p>hexane</p> <p>hexane</p>
<p>7</p> <p>7</p>	$ \begin{array}{cccccc} & \text{H} \\ & & & & & & & \\ \text{H} & - \text{C} & - \text{H} \\ & & & & & & & \\ & \text{H} \end{array} $	<p>hept-</p> <p>hept-</p>	<p>heptane</p> <p>heptane</p>
<p>8</p> <p>8</p>	$ \begin{array}{cccccc} & \text{H} \\ & & & & & & & & \\ \text{H} & - \text{C} & - \text{H} \\ & & & & & & & & \\ & \text{H} \end{array} $	<p>oct-</p> <p>oct-</p>	<p>octane</p> <p>octane</p>



26.5 Naming alkanes (p.66)

Table 26.10 Names and formulae of alkyl groups

Name of alkyl group	Formula
Methyl	$-\text{CH}_3$
Ethyl	$-\text{CH}_2\text{CH}_3$
Propyl	$-\text{CH}_2\text{CH}_2\text{CH}_3$
Butyl	$-\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$

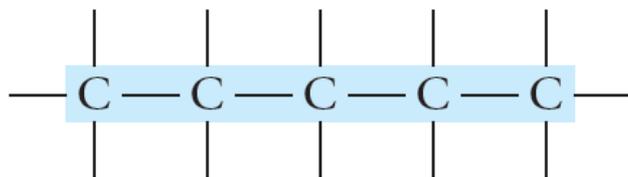


26.5 Naming alkanes (p.66)

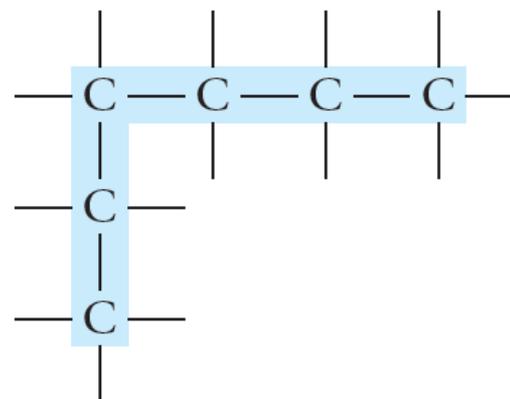
- ◆ To name a branched alkane:

1 Look for the longest continuous chain of carbon atoms.

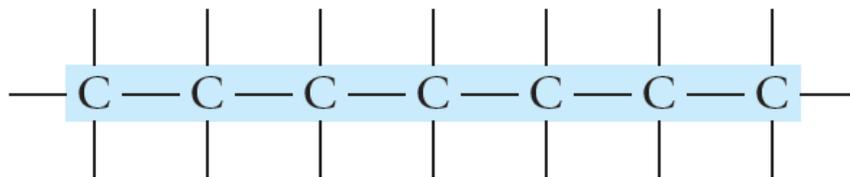
Examples:



pentane parent chain



hexane parent chain



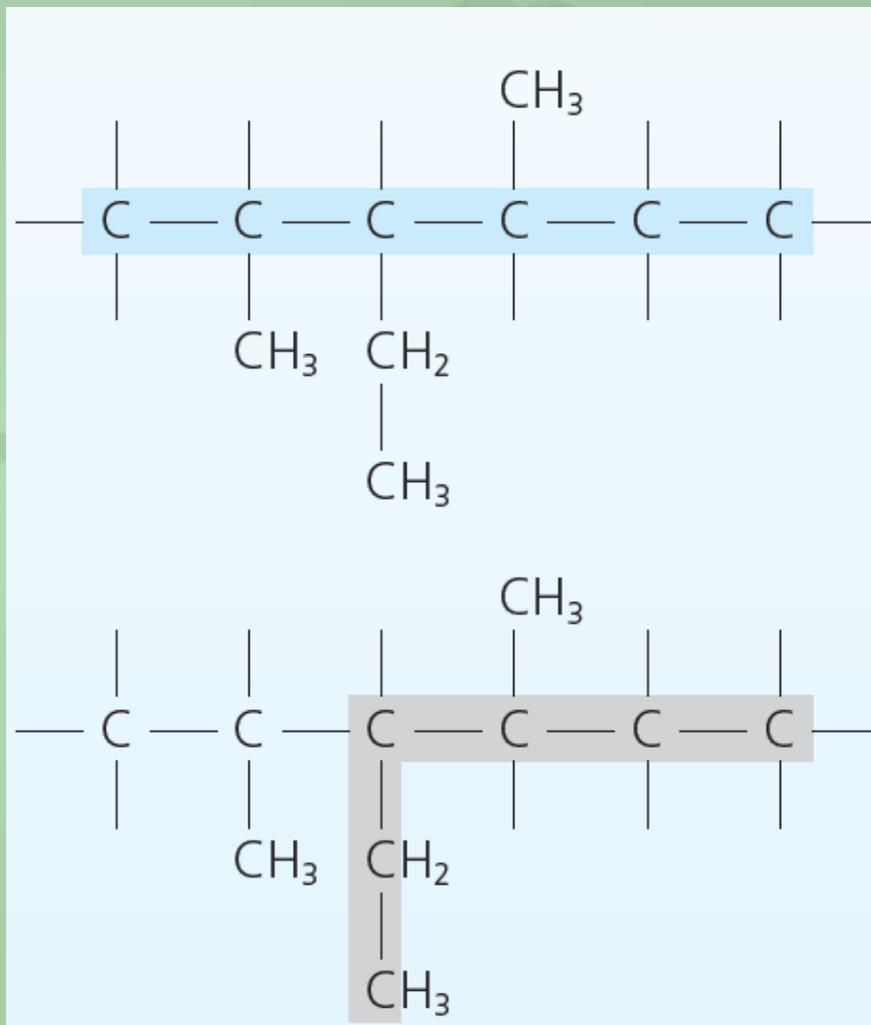
heptane parent chain



26.5 Naming alkanes (p.66)

Note:

For the same chain length, the one with most branches (the blue chain here) is considered the longest chain.

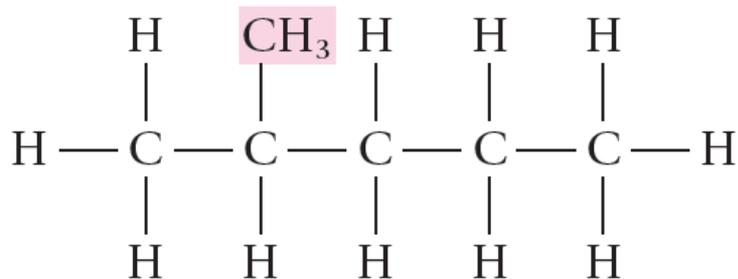




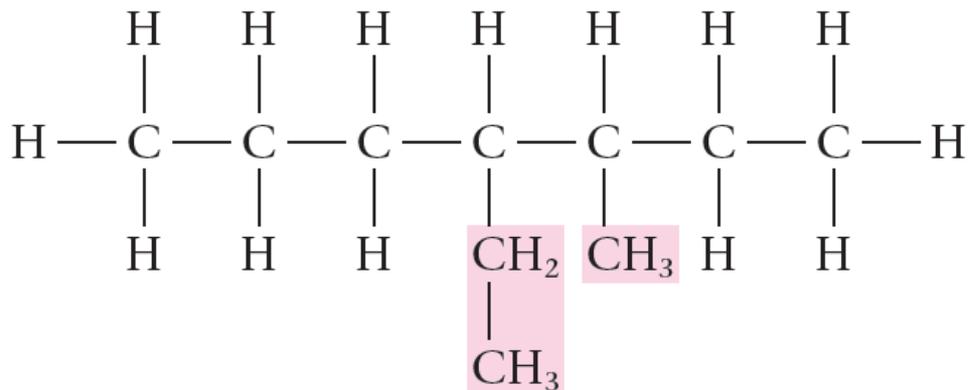
26.5 Naming alkanes (p.66)

2 Identify the alkyl group(s) attached to the parent chain.

Examples:



a methyl group attached to the pentane chain



an ethyl group and a methyl group attached to the heptane chain

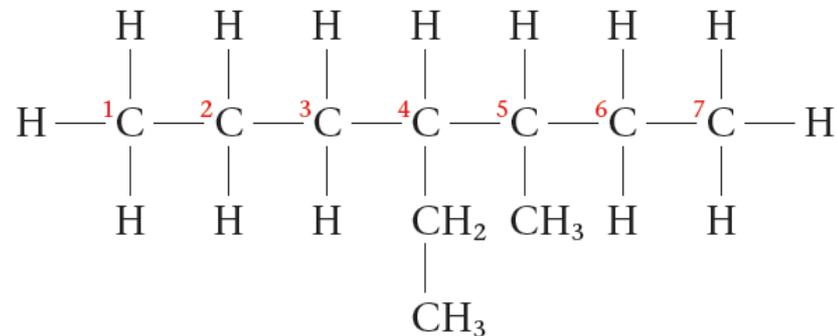
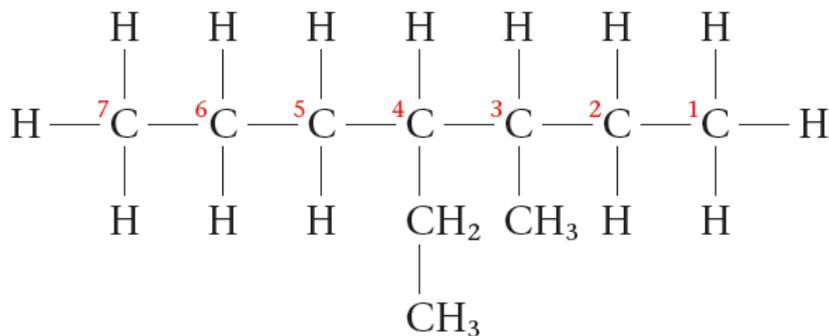
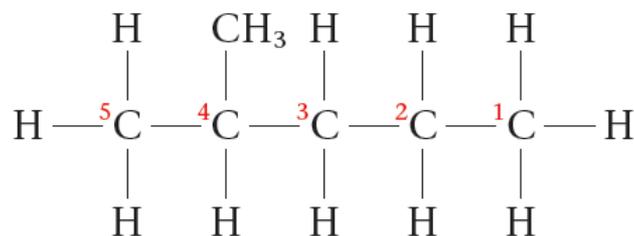
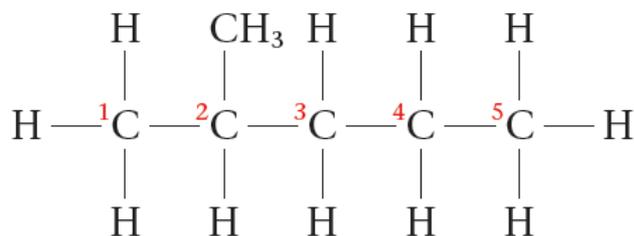


26.5 Naming alkanes (p.66)

3 Number the carbon atoms of the parent chain.

Examples:

The lowest number(s) should be given to the carbon atom(s) bearing the alky group(s).



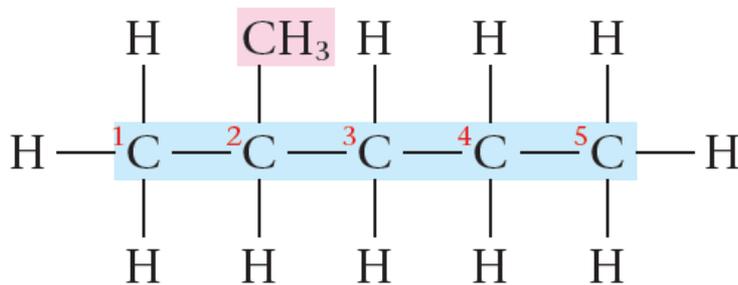


26.5 Naming alkanes (p.66)

4 Name the compound (alkyl groups arranged alphabetically):

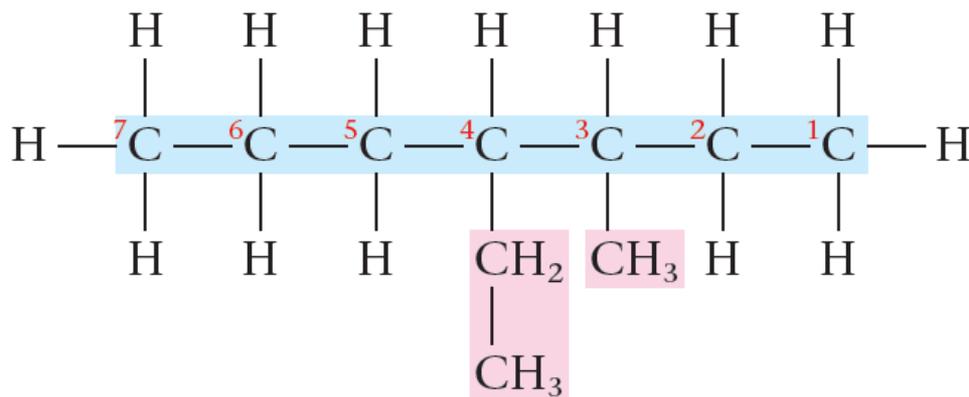
number on C, alkyl group attached, name of parent chain

Examples:



hyphen separating
number and letters

2-methylpentane



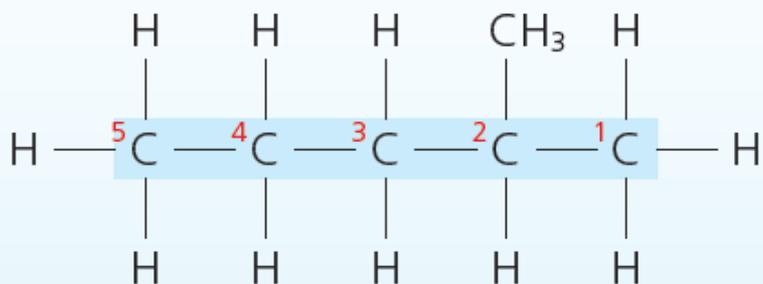
hyphens separating
numbers and letters

4-ethyl-3-methylheptane



26.5 Naming alkanes (p.66)

The following structural formula also represents 2-methylpentane.

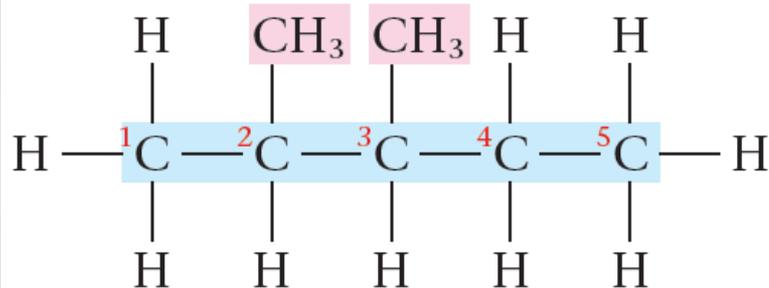




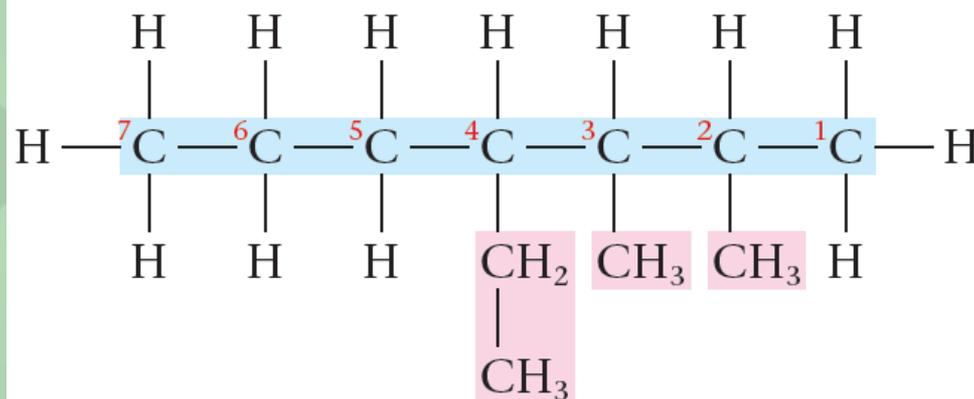
26.5 Naming alkanes (p.66)

5 Add 'di', 'tri' or 'tetra' for two or more of the same alkyl group. These prefixes do not affect the alphabetical order of the alkyl groups.

Examples:



2,3-dimethylpentane



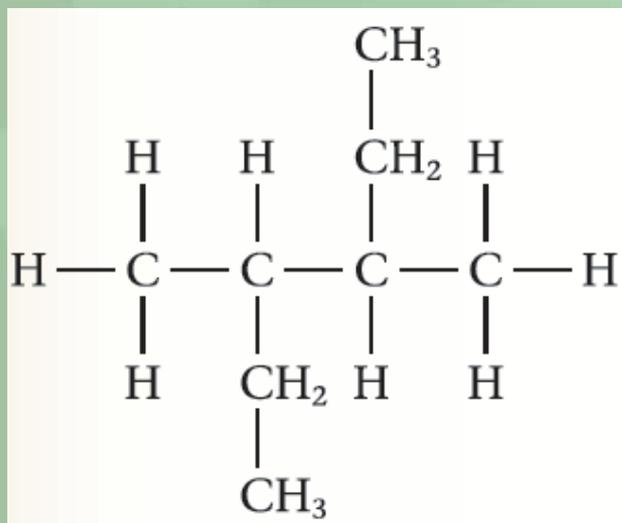
4-ethyl-2,3-dimethylheptane



26.5 Naming alkanes (p.66)

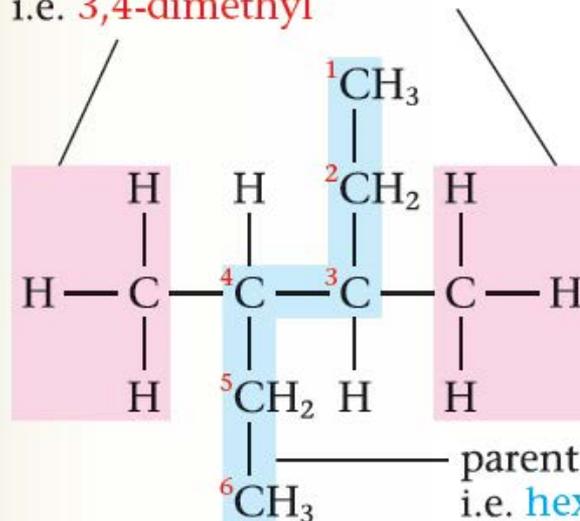
Q (Example 26.4)

Give the systematic name of the compound shown below.



A

a methyl group on each of carbon atoms 3 and 4,
i.e. **3,4-dimethyl**



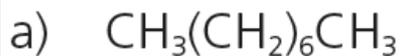
Thus, the systematic name of the compound is **3,4-dimethylhexane**.



26.5 Naming alkanes (p.66)

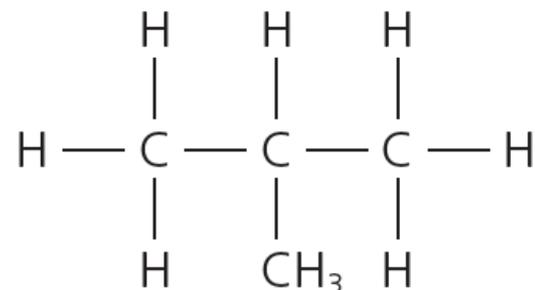
Practice 26.6

Give the systematic names of the alkanes below.

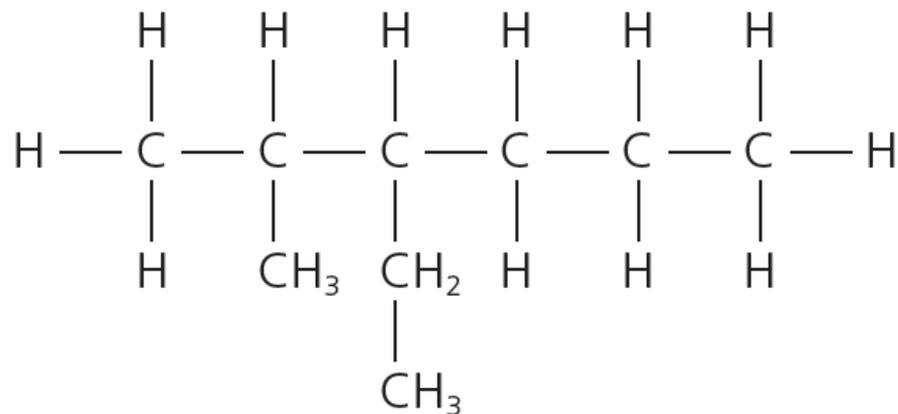


Octane

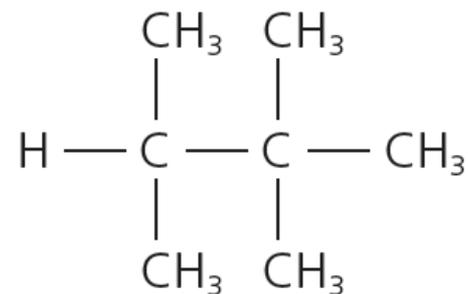
b)



c)



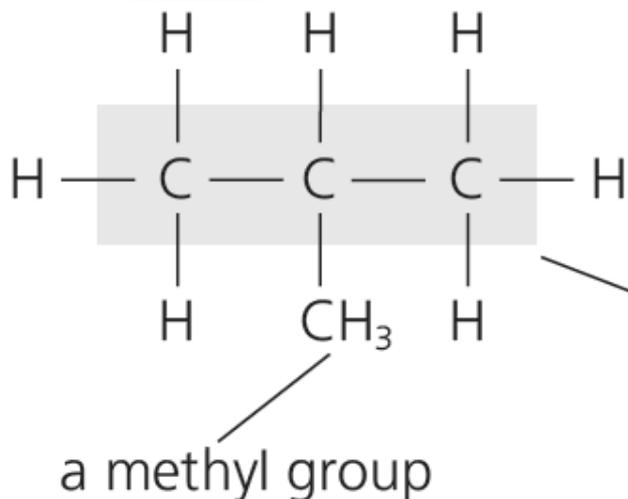
d)





26.5 Naming alkanes (p.66)

b)



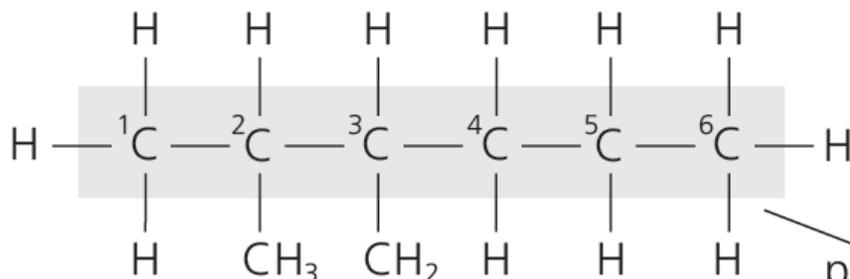
There is no need to assign a number to indicate the position of the methyl group as it can only be in one position.

Thus, the systematic name of this compound is methylpropane.



26.5 Naming alkanes (p.66)

c)



a methyl group on
carbon atom 2

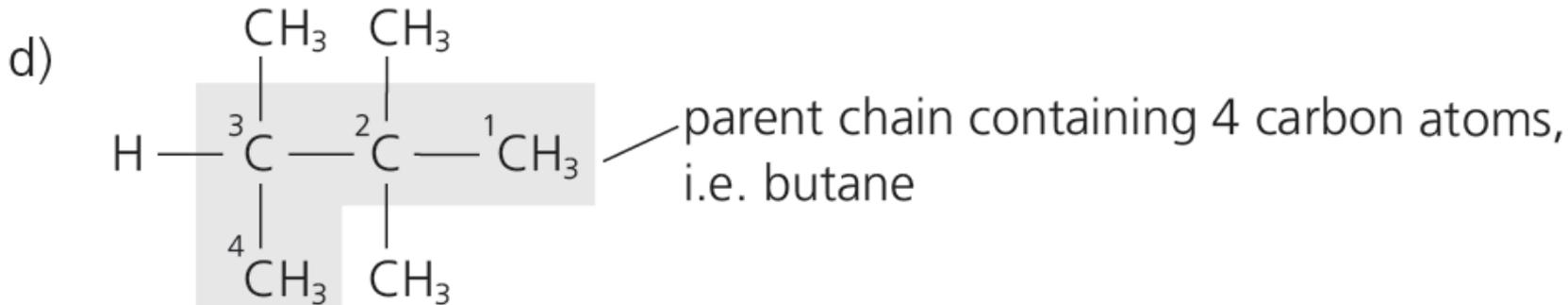
an ethyl group on
carbon atom 3

parent chain containing 6 carbon atoms,
i.e. hexane

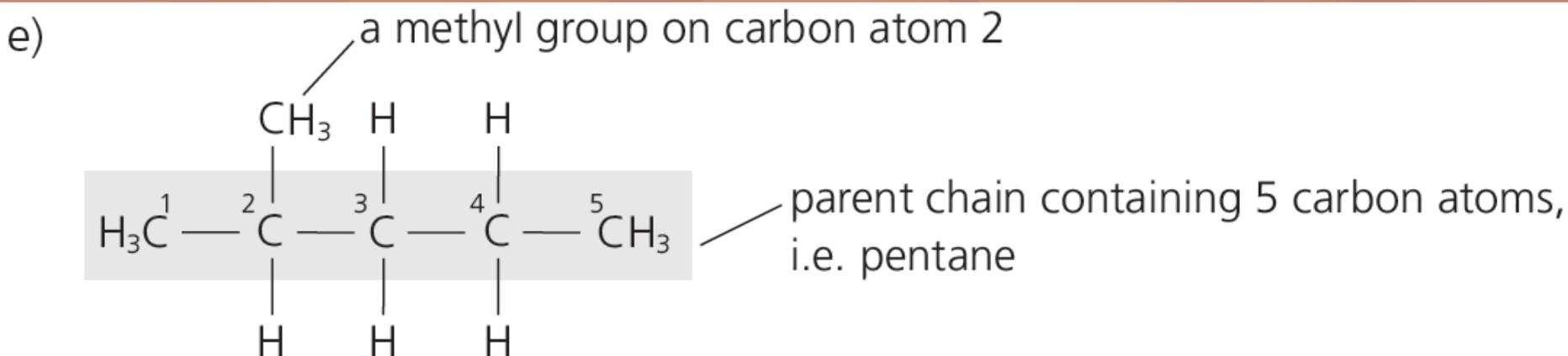
Thus, the systematic name of this compound is 3-ethyl-2-methylhexane.



26.5 Naming alkanes (p.66)



Thus, the systematic name of this compound is 2,2,3-trimethylbutane.



Thus, the systematic name of this compound is 2-methylpentane.



26.6 Writing structural formulae from systematic names (p.72)

Q (Example 26.5) A

Write the structural formula of the compound

2,2-dimethylpentane.

'2,2-dimethyl' indicates that there are two methyl groups on carbon atom 2

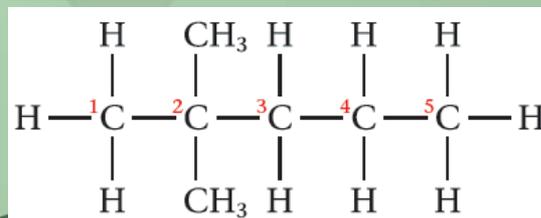
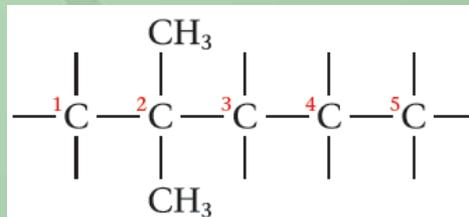
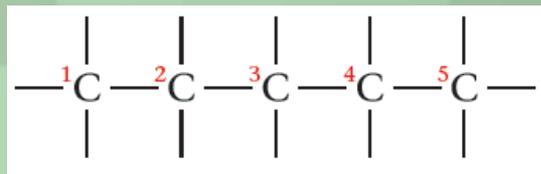
'pent' indicates a parent chain of 5 carbon atoms while 'ane' indicates that the compound is an alkane.

2,2-dimethylpentane

Numbering this straight chain from left to right establishes the locations of the alkyl groups

The numbers '2,2' indicates that the methyl groups are on carbon atom 2.

Thus, the structural formula of 2,2-dimethylpentane is



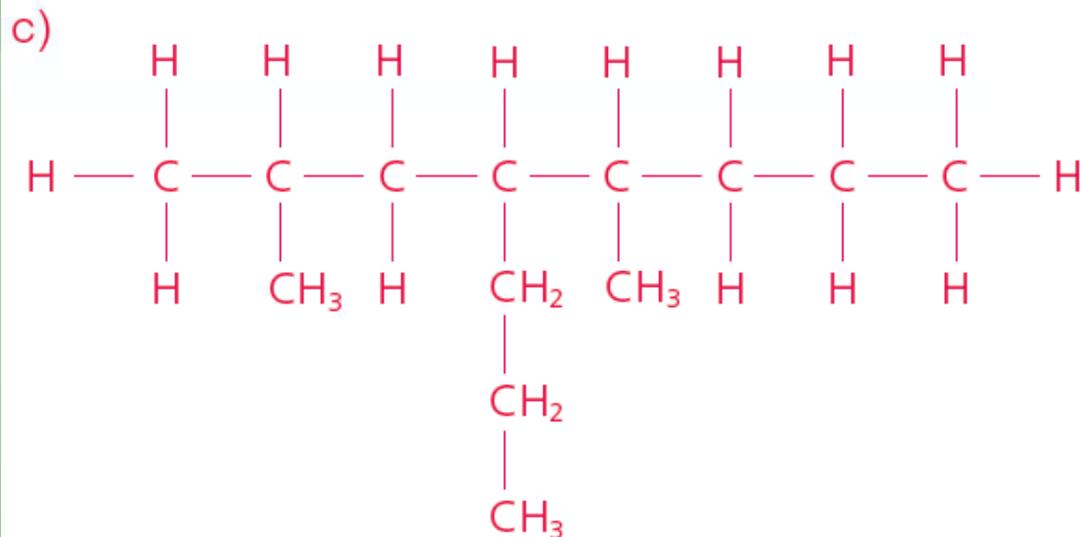
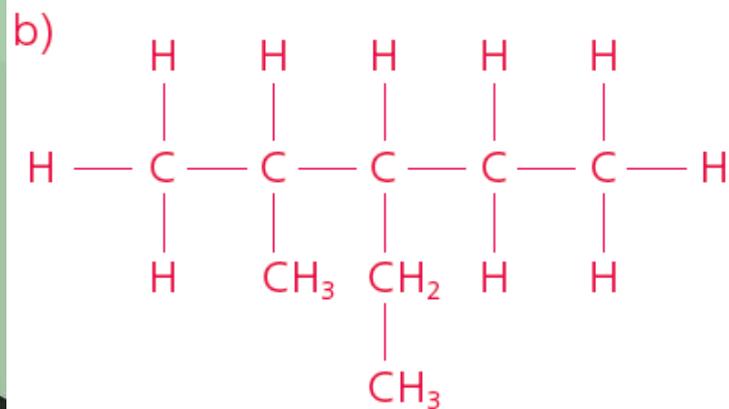
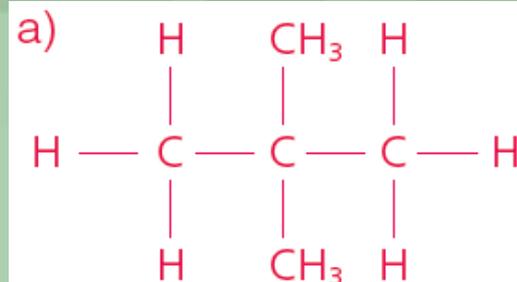


26.6 Writing structural formulae from systematic names (p.72)

Practice 26.7

Write the structural formulae of the compounds below.

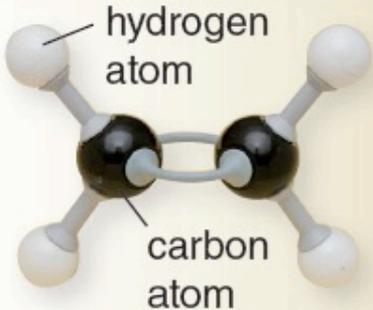
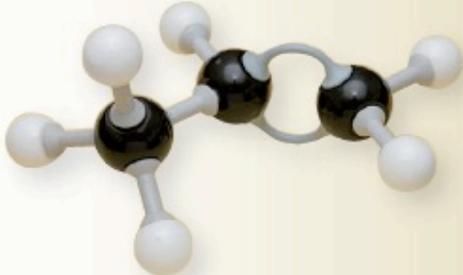
- dimethylpropane
- 3-ethyl-2-methylpentane
- 2,5-dimethyl-4-propyloctane





26.7 Naming alkenes (p.73)

- Alkene ($-\text{C}=\text{C}-$): C_nH_{2n} , having two fewer hydrogen atoms than the corresponding alkane and called **unsaturated hydrocarbons** (不飽和烴).

Ethene	$\text{CH}_2=\text{CH}_2$	
Propene	$\text{CH}_3\text{CH}=\text{CH}_2$	

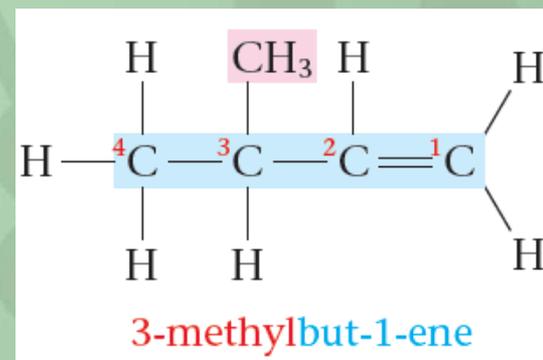
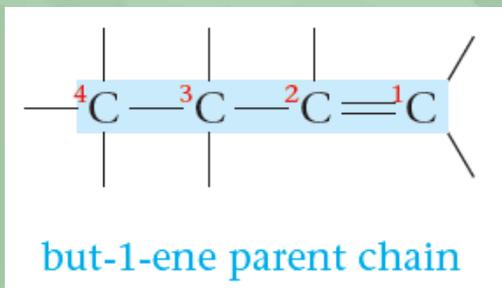
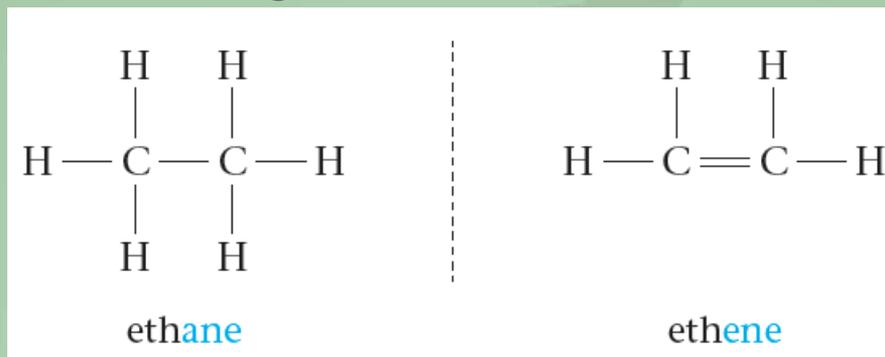


Building molecular models of alkenes



26.7 Naming alkenes (p.73)

- Alkenes are named using rules similar to those for alkanes.

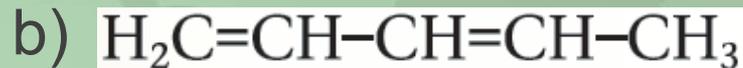
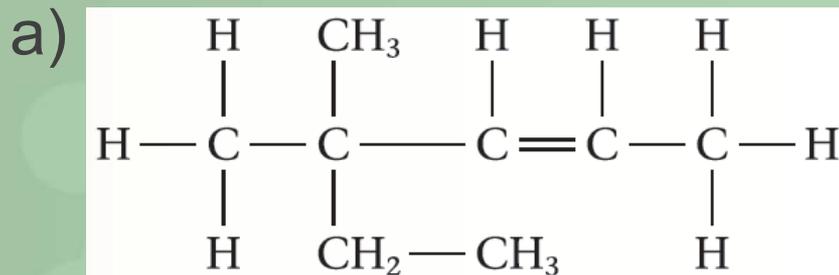




26.7 Naming alkenes (p.73)

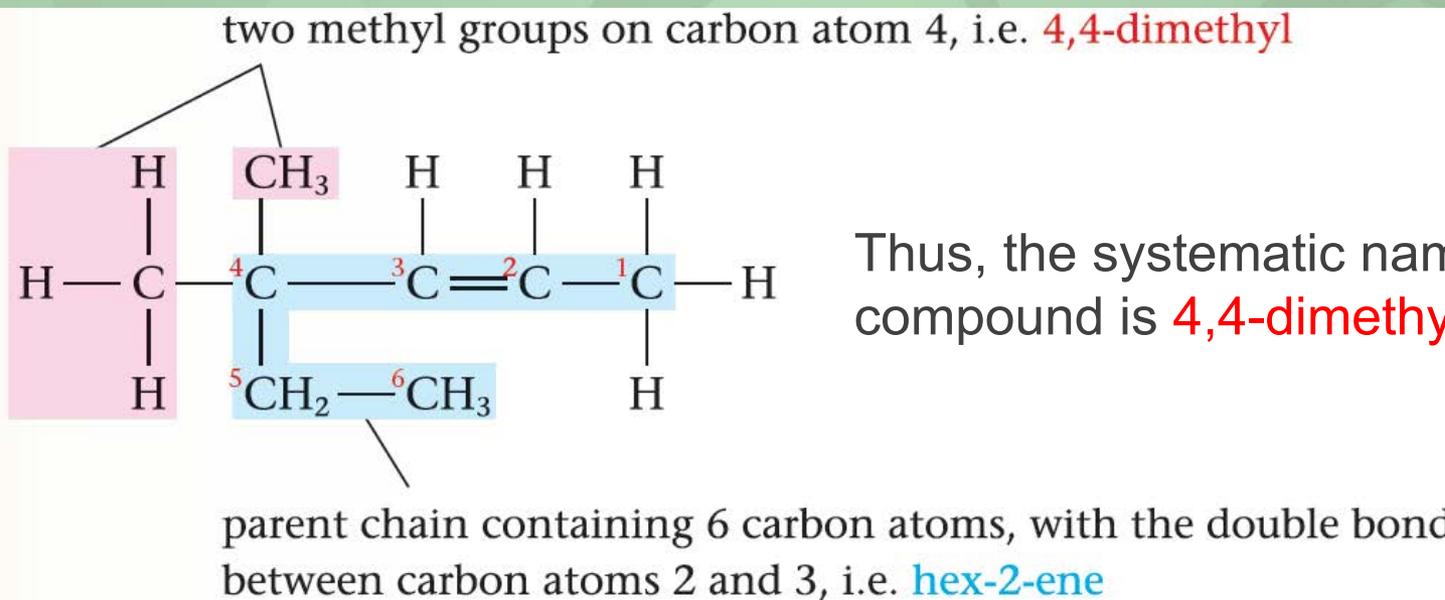
Q (Example 26.6)

Write the systematic names of the compounds below.



A

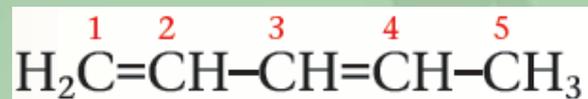
a)





26.7 Naming alkenes (p.73)

b) A hydrocarbon that contains two carbon-carbon double bonds is called a diene.



The parent chain contains 5 carbon atoms, with one double bond between carbon atoms 1 and 2, and another double bond between carbon atoms 3 and 4.

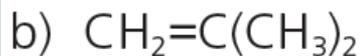
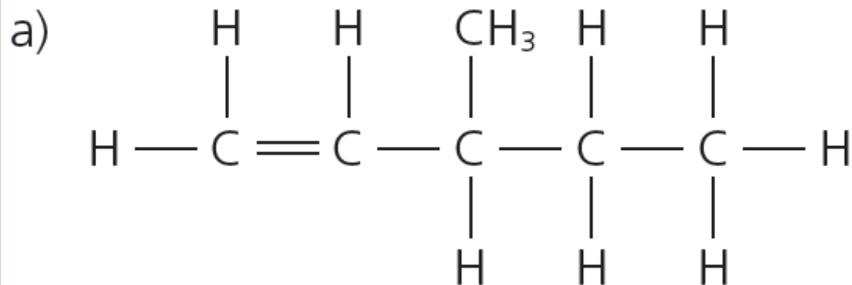
Thus, the systematic name of this compound is penta-1,3-diene.



26.7 Naming alkenes (p.73)

Practice 26.8

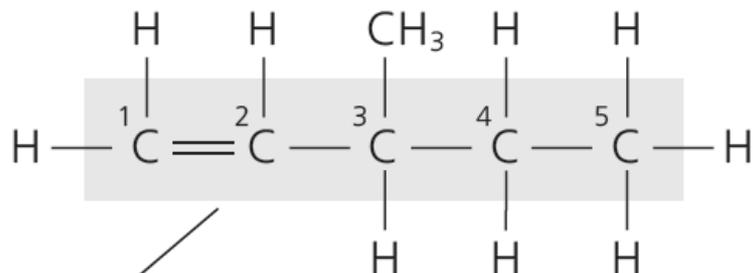
1 Write the systematic names of the compounds shown.





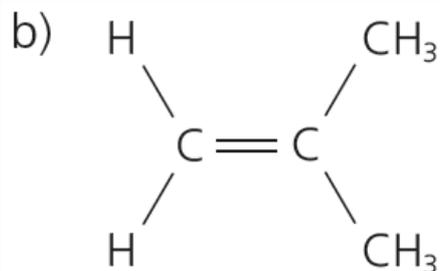
26.7 Naming alkenes (p.73)

a) a methyl group on carbon atom 3



parent chain containing 5 carbon atoms, with the double bond between carbon atoms 1 and 2, i.e. pent-1-ene

Thus, the systematic name of this compound is 3-methylpent-1-ene.



The systematic name of this compound is methylpropene.



26.7 Naming alkenes (p.73)

2 Write the structural formulae of the compounds below.

a) 2-propylpent-1-ene



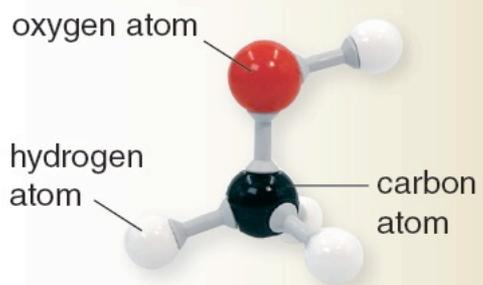
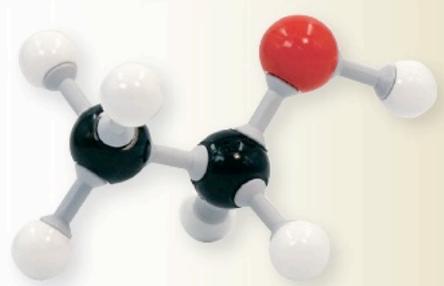
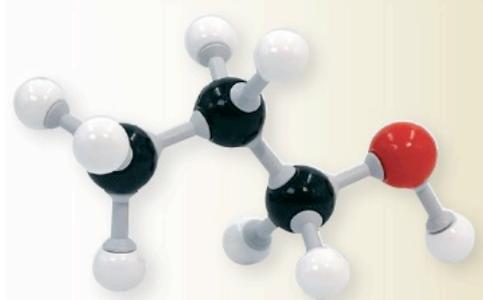
b) 4-ethyl-2-methylhex-3-ene





26.8 Naming alkanols (p.76)

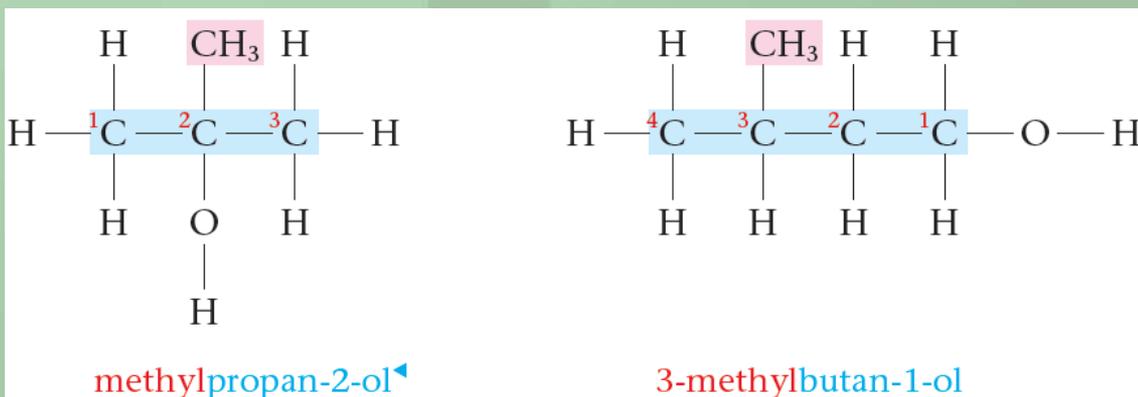
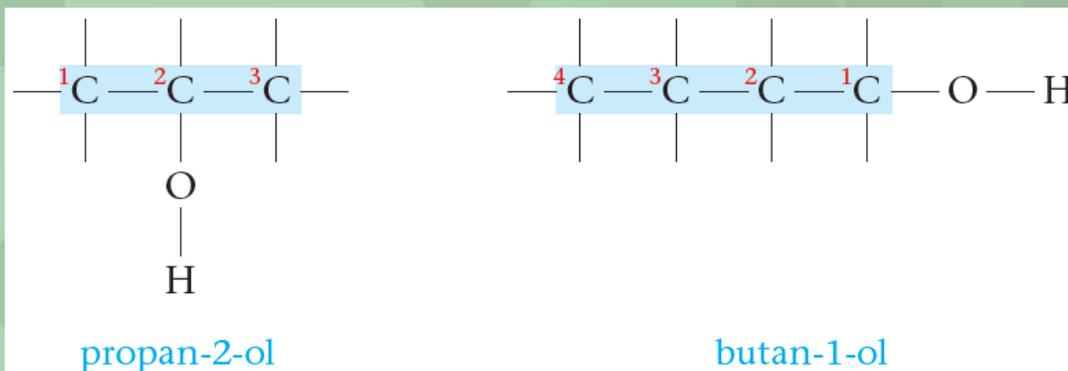
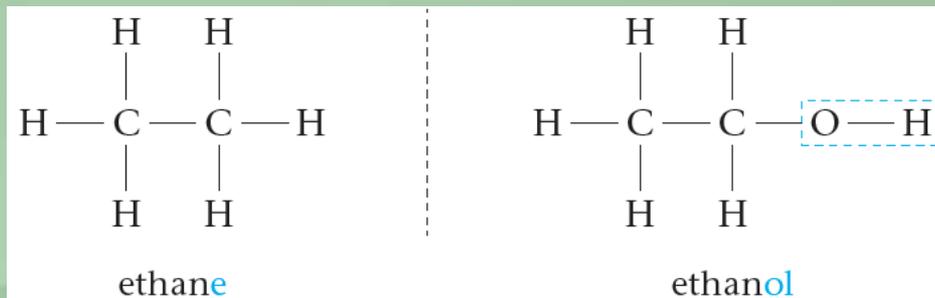
- Alkanols (-O-H):
 $C_nH_{2n+1}OH$

Methanol	CH_3OH	
Ethanol	CH_3CH_2OH	
Propan-1-ol	$CH_3CH_2CH_2OH$	



26.8 Naming alkanols (p.76)

- ◆ Replace the 'e' at the end of the name of the corresponding alkane parent chain with the suffix -ol.
- ◆ Number from the end nearest to -O-H.
- ◆ Indicate any alkyl group present.



▶ There is no need to assign a number to indicate the position of the methyl group as it can only be in one position.

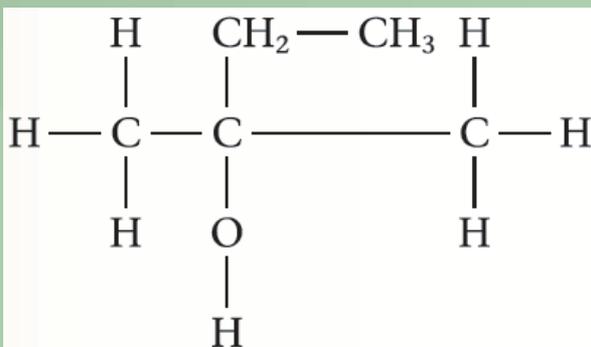


26.8 Naming alkanols (p.76)

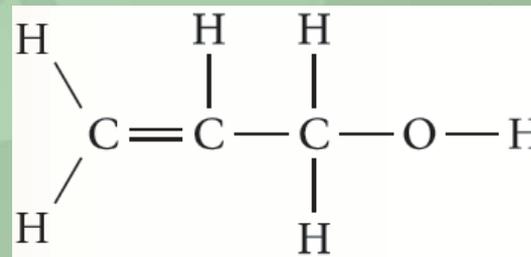
Q (Example 26.7)

Give the systematic names of the compounds below.

a)

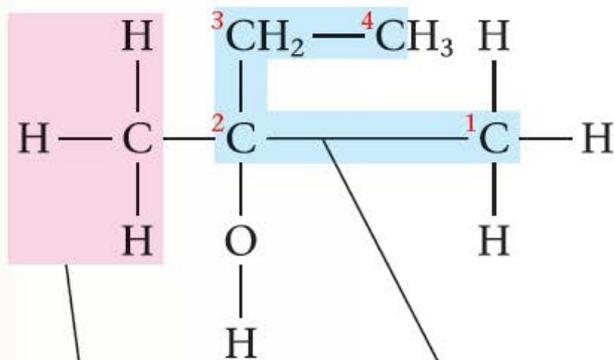


b)



A

a)



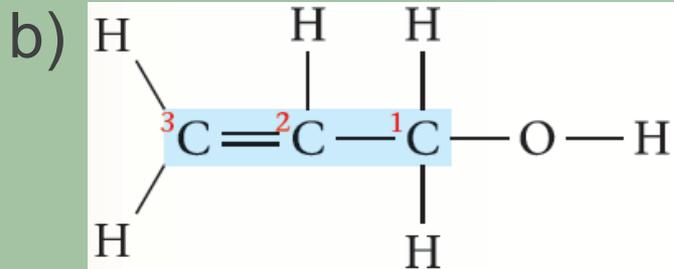
methyl group on carbon atom 2, i.e. **2-methyl**

parent chain containing 4 carbon atoms, with the $-\text{O}-\text{H}$ group on carbon atom 2, i.e. **butan-2-ol**

Thus, the systematic name of the compound is **2-methylbutan-2-ol**.



26.8 Naming alkanols (p.76)



The parent chain contains 3 carbon atoms and a carbon-carbon double bond. The compound can be regarded as a derivative of propene.

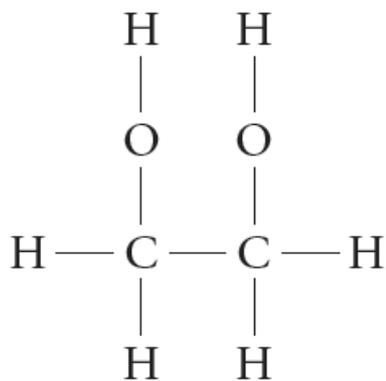
Take the $-\text{O}-\text{H}$ group to be on carbon atom 1. Add the suffix '-en-' and a number '2' to indicate the carbon-carbon double bond and its location.

Thus, the systematic name of the compound is prop-2-en-1-ol.

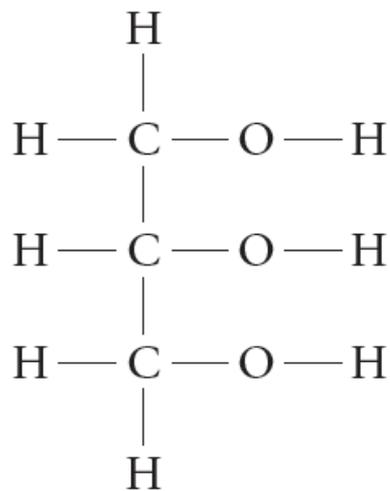


26.8 Naming alkanols (p.76)

- Alcohols can have more than one hydroxyl group.



ethane-1,2-diol

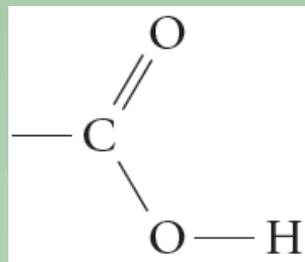


propane-1,2,3-triol

Notice that the last letter 'e' in the name of the corresponding alkane is NOT removed when naming an alcohol containing more than one -O-H group.



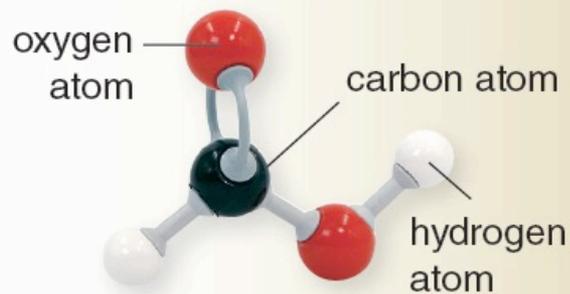
26.9 Naming alkanolic acids (p.79)



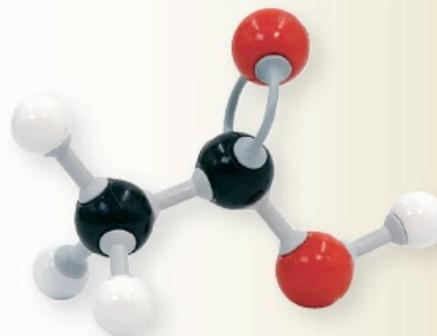
- ◆ Alkanolic acids ($-\text{COOH}$ or $-\text{CO}_2\text{H}$): $\text{C}_n\text{H}_{2n+1}\text{COOH}$
- ◆ The functional group is called a carboxyl group.



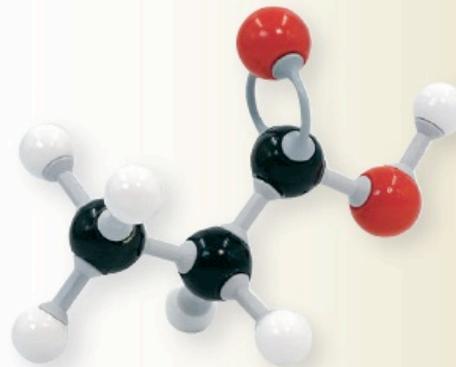
Methanoic acid



Ethanoic acid



Propanoic acid

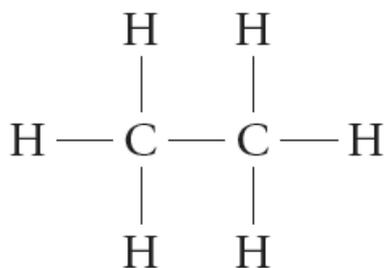


Building molecular models of alkanols and alkanolic acids

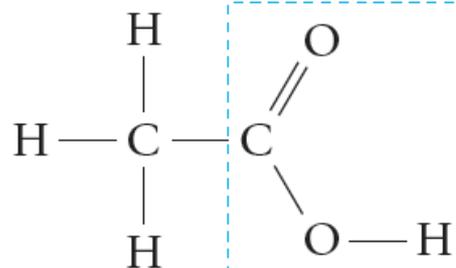


26.9 Naming alkanolic acids (p.79)

- ◆ Replace 'e' at the end of the name of the corresponding alkane parent chain with the suffix **-oic acid**.
- ◆ There's no need to indicate the location of the functional group because it must lie at the end of the parent chain.
- ◆ Alkyl groups on the parent chain are named in the usual way.



ethane



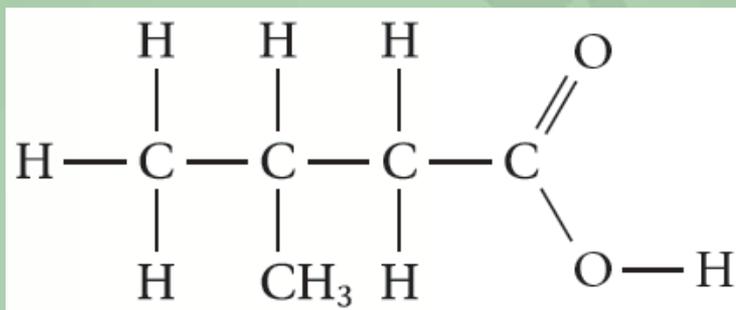
ethanoic acid



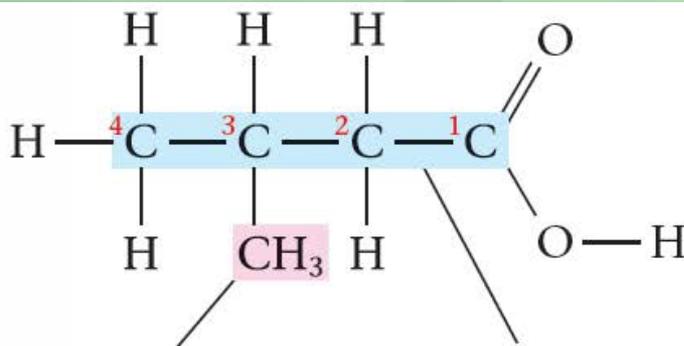
26.9 Naming alkanolic acids (p.79)

Q (Example 26.8)

Give the systematic name of the compound below.



A



Thus, the systematic name of the compound is **3-methylbutanoic acid**.

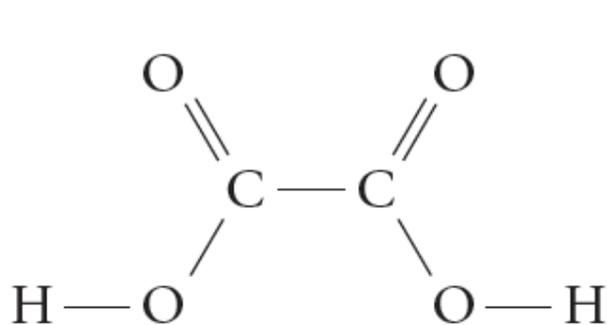
a methyl group on carbon atom 3, i.e. **3-methyl**

parent chain containing 4 carbon atoms, i.e. **butanoic acid**

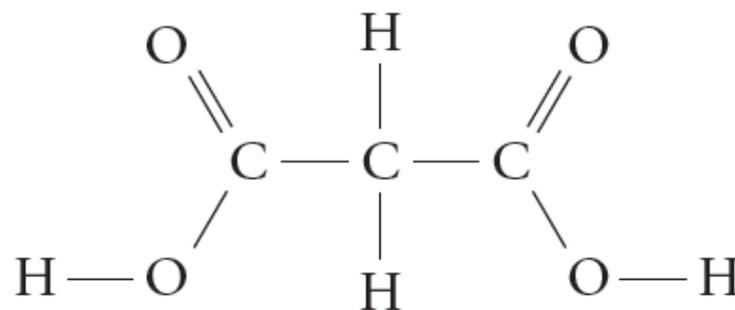


26.9 Naming alkanolic acids (p.79)

- Some acids contain two carboxylic groups—called **-dioic acids**.



ethanedioic acid



propanedioic acid

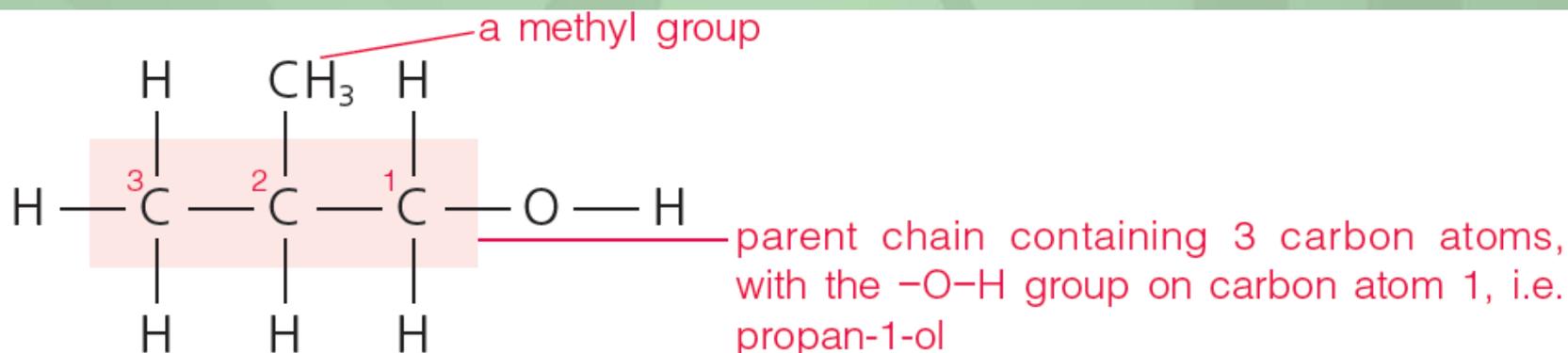
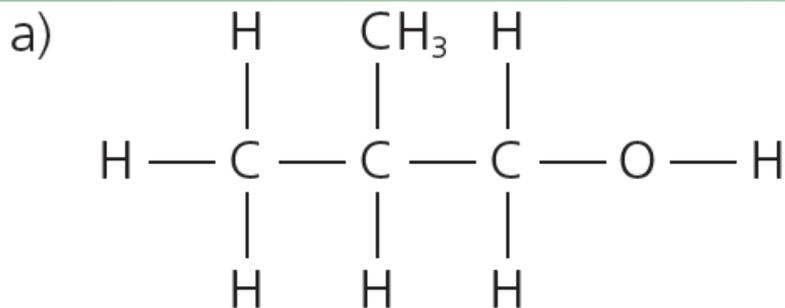
DSE 2013 Paper 1B Q4(a)



26.9 Naming alkanolic acids (p.79)

Practice 26.9

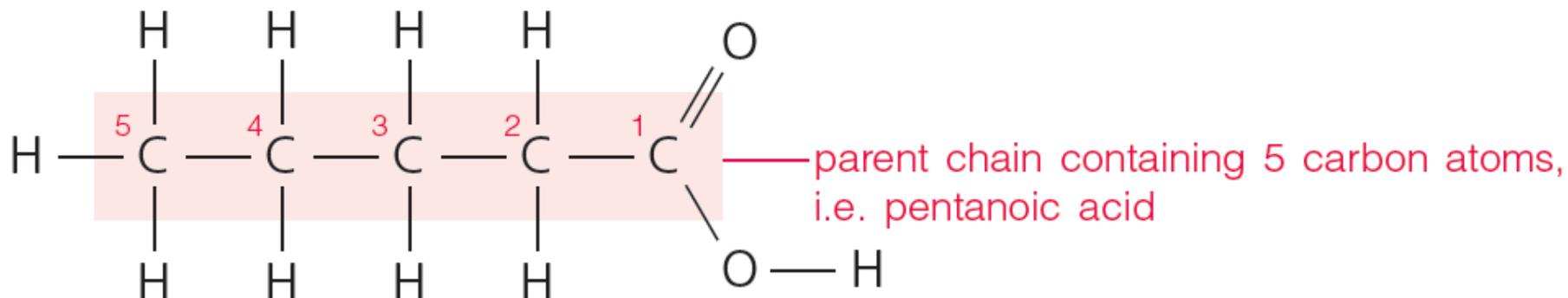
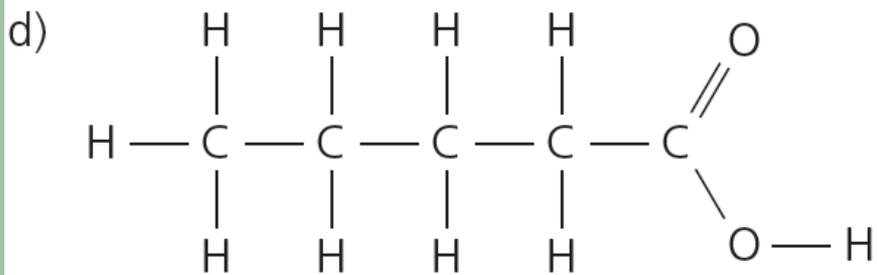
1 Give the systematic names of the compounds below.



Thus, the systematic name of this compound is methylpropan-1-ol.



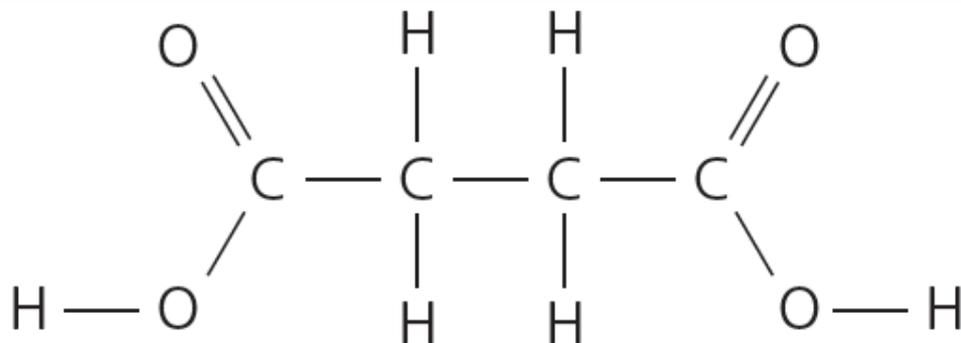
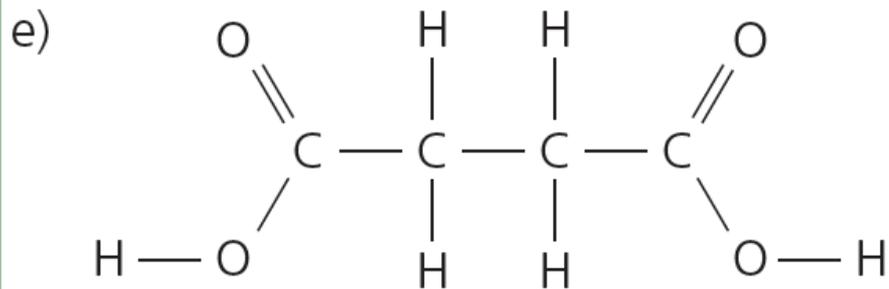
26.9 Naming alkanolic acids (p.79)



Thus, the systematic name of this compound is pentanoic acid.



26.9 Naming alkanolic acids (p.79)



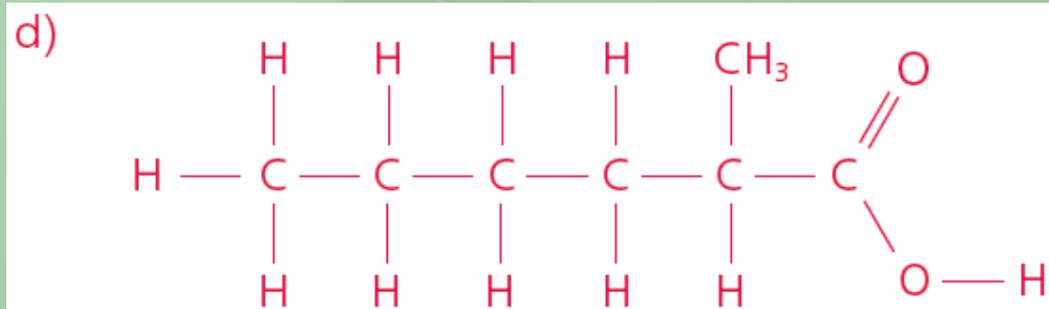
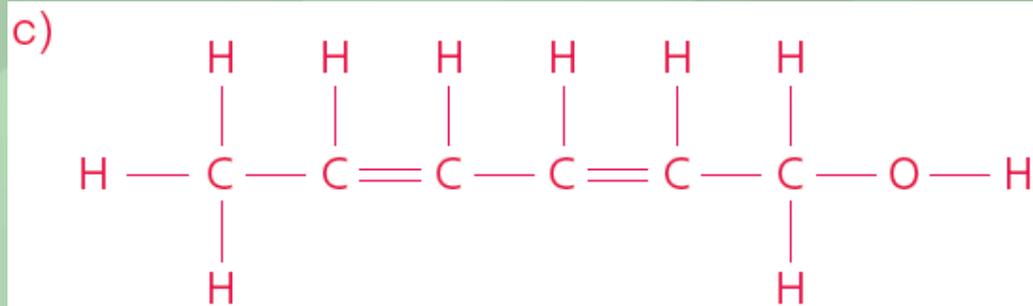
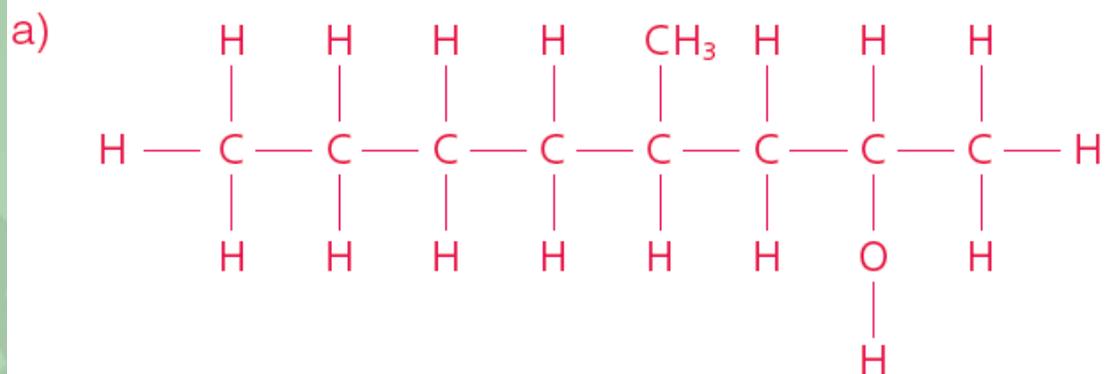
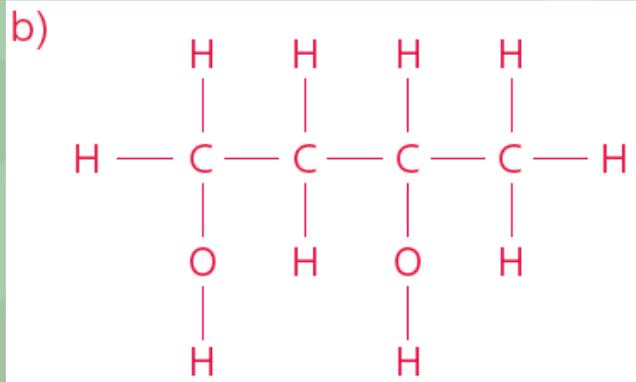
The systematic name of this compound is butanedioic acid.



26.9 Naming alkanoic acids (p.79)

2 Write the structural formulae of the compounds below.

- 4-methyloctan-2-ol
- butane-1,3-diol
- hexa-2,4-dien-1-ol
- 2-methylhexanoic acid





26.10 Physical properties of alkanes (p.83)

Melting and boiling points of alkanes

- ◆ As the carbon chain length increases,
 - the molecular size and the number of electrons per molecule also increase,
 - so the van der Waals' forces between the molecules increase.
 - Thus, the melting and boiling points of alkanes increase.
- ◆ Gases: methane to butane
- ◆ Liquid: pentane
- ◆ Solid: at a chain length of about 18

Paraffin wax is a mixture of solid alkanes with 20 or more carbon atoms per molecule





26.10 Physical properties of alkanes (p.83)

▶ **Table 26.14** Melting and boiling points of the first ten straight-chain alkanes

Name	Condensed structural formula	Melting point (°C)	Boiling point (°C)
Methane	CH ₄	-182	-162
Ethane	CH ₃ CH ₃	-183	-89
Propane	CH ₃ CH ₂ CH ₃	-190	-42
Butane	CH ₃ CH ₂ CH ₂ CH ₃	-138	-0.5
Pentane	CH ₃ CH ₂ CH ₂ CH ₂ CH ₃	-130	36
Hexane	CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ CH ₃	-95	69
Heptane	CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ CH ₂ CH ₃	-91	98
Octane	CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ CH ₂ CH ₂ CH ₃	-57	126
Nonane	CH ₃ CH ₂ CH ₃	-51	151
Decane	CH ₃ CH ₂ CH ₃	-30	174



26.10 Physical properties of alkanes (p.83)

Solubility

- ◆ Alkanes are insoluble in water.
- ◆ This is because water molecules are held together by hydrogen bonds which are much stronger than the van der Waals' forces that act between alkane molecules.
- ◆ The attractive forces between alkane molecules and water molecules are weaker in comparison.
- ◆ Hence alkane molecules and water molecules do not mix easily.

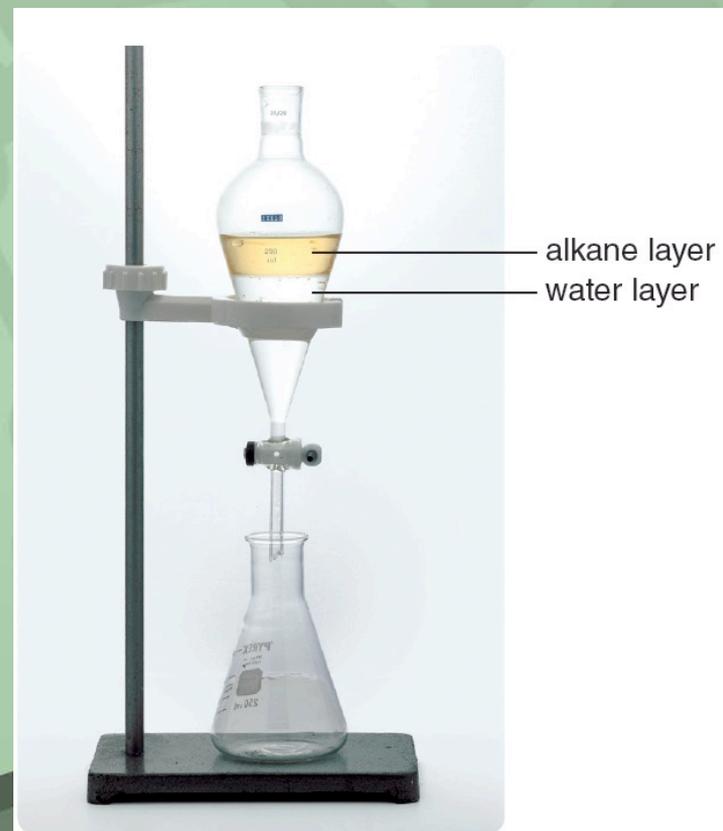


26.10 Physical properties of alkanes (p.83)

- ◆ A mixture of liquid alkane and water can be separated by using a **separating funnel** (分液漏斗).
- ◆ However, alkanes do not mix with relatively non-polar liquids such as cyclohexane.

Density

- ◆ At room temperature, liquid alkanes are less dense than water.
- ◆ On mixing and settling, they form two **immiscible** (不互溶的) layers with alkane on top.





26.10 Physical properties of alkanes (p.83)

Practice 26.10

The table below lists the boiling points of some straight-chain alkanes.

Alkane	Molecular formula	Boiling point (°C)
Heptane	C_7H_{16}	98
Octane	C_8H_{18}	126
Nonane	C_9H_{20}	151
Decane	$C_{10}H_{22}$	174
Undecane	$C_{11}H_{24}$?
Dodecane	?	214



26.10 Physical properties of alkanes (p.83)

a) Alkanes form a homologous series. What do you understand about the term 'homologous series'.

A 'family' of compounds that have a common functional group, with each successive member differing by a $-\text{CH}_2-$ unit, is called a homologous series.

b) Deduce the molecular formula of dodecane with 12 carbon atoms per molecule. $\text{C}_{12}\text{H}_{26}$

c) Deduce the boiling point of undecane ($\text{C}_{11}\text{H}_{24}$).

About $194\text{ }^\circ\text{C}$ (actual $196\text{ }^\circ\text{C}$)



26.10 Physical properties of alkanes (p.83)

d) The boiling point of 2,2,4-trimethylpentane is 99 °C.

i) Write the skeletal formula of 2,2,4-trimethylpentane.



ii) Octane and 2,2,4-trimethylpentane have the same molecular formula C_8H_{18} . Explain why the boiling point of octane is higher than that of 2,2,4-trimethylpentane.

The octane molecule is longer and somewhat spread out. The molecule has a larger surface area, allowing a greater area of contact with neighbouring molecules.

In contrast, the 2,2,4-trimethylpentane molecule is more compact, adopting a roughly spherical shape. The molecule has a smaller surface area for coming into contact with neighbouring molecules.

Thus, the van der Waals' forces among octane molecules are stronger than those among 2,2,4-trimethylpentane molecules.



Key terms (p.87)

structural formula	結構式	carboxyl group	羧基
condensed structural formula	簡明結構式	alkanoic acid	烷酸
skeletal formula	骨架式	general formula	通式
hydroxyl group	羥基	suffix	詞尾
functional group	官能基	prefix	詞首
homologous series	同系列	unsaturated hydrocarbon	不飽和烴
alkene	烯	separating funnel	分液漏斗
alkanol	烷醇	immiscible	不互溶的



Summary (p.88)

- 1 The structural formulae, condensed structural formulae and skeletal formulae of three different compounds with the same molecular formula C_5H_{12} are shown below.

Structural formula	Condensed structural formula	Skeletal formula
$ \begin{array}{ccccccccc} & H & & H & & H & & H & & H \\ & & & & & & & & & \\ H & - C & - & C & - & C & - & C & - & C & - H \\ & & & & & & & & & \\ & H & & H & & H & & H & & H \end{array} $	$CH_3CH_2CH_2CH_2CH_3$ or $CH_3(CH_2)_3CH_3$	
$ \begin{array}{ccccccc} & & H & & & & \\ & & & & & & \\ & H & - C & - & H & & \\ & & & & & H & & H \\ & H & & & H & & & H \\ H & - C & - & C & - & C & - & C & - H \\ & & & & & & & \\ & H & & H & & H & & H \end{array} $	$(CH_3)_2CHCH_2CH_3$ or $CH_3CH_2CH(CH_3)_2$	
$ \begin{array}{ccccccc} & & H & & & & \\ & & & & & & \\ & H & - C & - & H & & \\ & & & & & H & & H \\ & H & & & H & & & H \\ H & - C & - & C & - & C & - & H \\ & & & & & & & \\ & H & & H & & H & & \\ & & H & & & H & & \\ & & & & & & & \\ & & H & & & & & \end{array} $	$C(CH_3)_4$	



Summary (p.88)

- 2 A functional group is either a single atom or a group of atoms which determines most of the properties of a compound.
- 3 Members in a homologous series show the following characteristics:
 - a) They have the same general formula.
 - b) Each member differs from the next by a $-\text{CH}_2-$ unit.
 - c) They show similar chemical properties.
 - d) Their physical properties show a gradual change from one to the next.
- 4 The general formula for alkanes is $\text{C}_n\text{H}_{2n+2}$, where n is the number of carbon atoms present.

 Summary (p.88)

5 Systematic names of the first eight straight-chain alkanes and the corresponding stems are shown below.

Number of carbon atoms per molecule	Condensed structural formula	Stem name	Systematic name
1	CH ₄	meth-	methane
2	CH ₃ CH ₃	eth-	ethane
3	CH ₃ CH ₂ CH ₃	prop-	propane
4	CH ₃ CH ₂ CH ₂ CH ₃	but-	butane
5	CH ₃ CH ₂ CH ₂ CH ₂ CH ₃	pent-	pentane
6	CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ CH ₃	hex-	hexane
7	CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ CH ₂ CH ₃	hept-	heptane
8	CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ CH ₂ CH ₂ CH ₃	oct-	octane



Summary (p.88)

- 6 Follow the IUPAC rules when naming branched-chain alkanes.
- Look for the longest continuous chain of carbon atoms (the parent chain).
 - Identify the alkyl group(s) attached to the parent chain.
 - Number the carbon atoms of the parent chain, starting from the end nearest to the alkyl group(s).
 - Name the compound using the name of the parent chain, prefixed by the name of each alkyl group and the number on the carbon atom in the parent chain to which the alkyl group is attached.
When there is more than one type of alkyl group, arrange them alphabetically.
 - When there are two or more of the same alkyl group, add the prefix 'di', 'tri' or 'tetra' (for two, three or four).



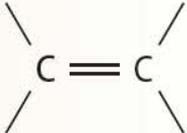
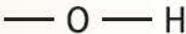
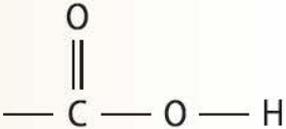
Summary (p.88)

- 7 Alkenes form a homologous series in which the functional group is a carbon-carbon double bond (C=C). The general formula of alkenes is C_nH_{2n} where n is the number of carbon atoms present.
- 8 Alkenes are unsaturated hydrocarbons.



Summary (p.88)

9 The table below summarises the information of some common homologous series.

Homogenous series	Functional group	Naming	Example(s)
Alkenes		replace the suffix -ane in the name of the corresponding alkane by the suffix -ene; insert a number before -ene to indicate the location of the C=C bond	$\text{CH}_3\text{CH}_2\text{CH}=\text{CH}_2$ but-1-ene $\text{CH}_3\text{CH}=\text{CHCH}_3$ but-2-ene
Alkanols		replace the last letter 'e' in the name of the corresponding alkane by the suffix -ol; insert a number before -ol to indicate the location of the -O-H group	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ butan-1-ol $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$ butan-2-ol
Alkanoic acids		replace the last letter 'e' in the name of the corresponding alkane by the suffix -oic acid; the carbon atom of the -COOH group is assigned number 1	$\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$ butanoic acid



Summary (p.88)

- 10 a) The melting points and boiling points of alkanes increase as the carbon chain lengths in molecules increase.
- b) Alkanes are insoluble in water.
- c) Liquid alkanes are less dense than water.



Unit Exercise (p.91)

Note: Questions are rated according to ascending level of difficulty (from 1 to 5):



question targeted at level 3 and above;



question targeted at level 4 and above;



question targeted at level 5.

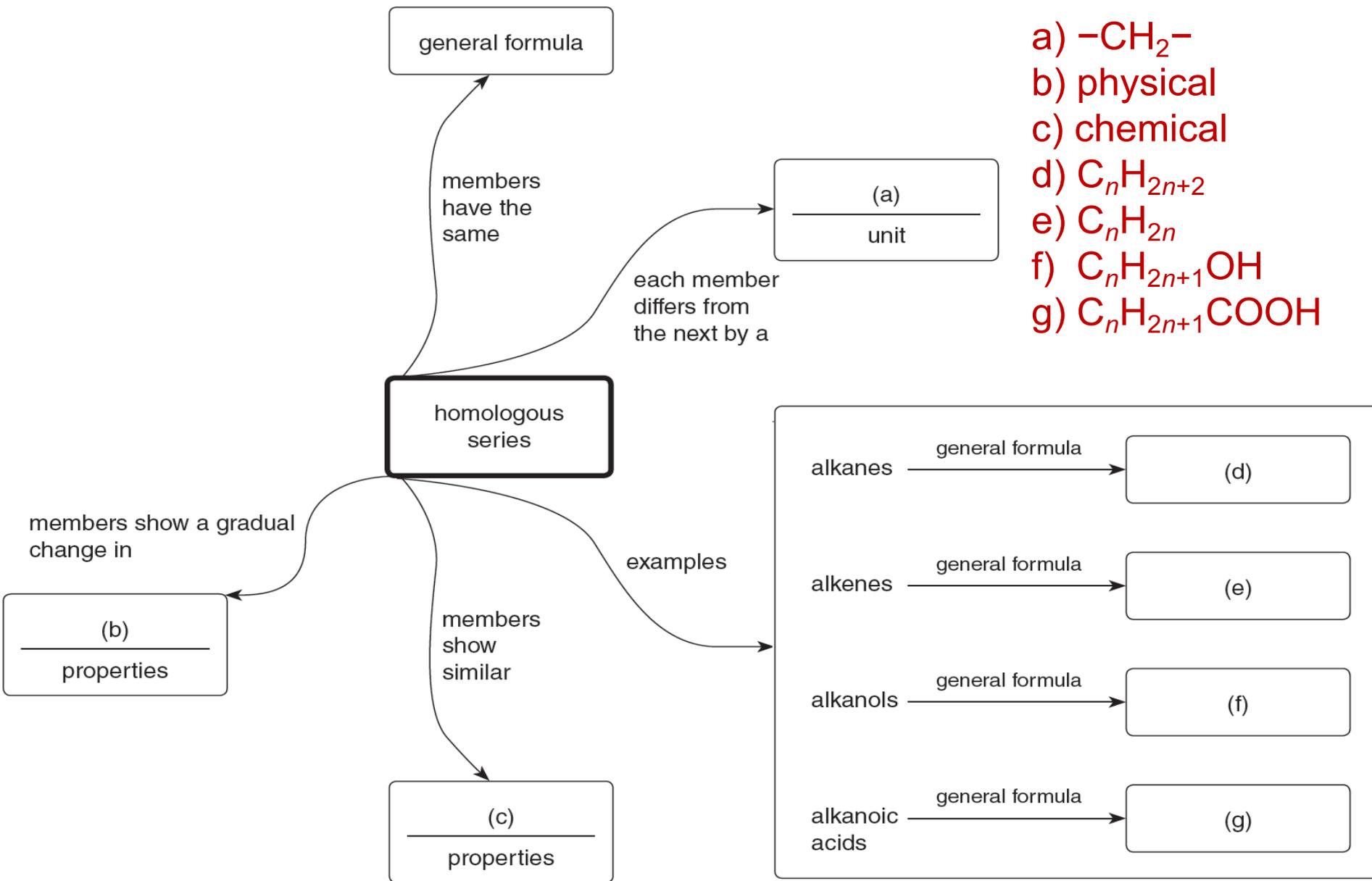
' * ' indicates 1 mark is given for effective communication.

Unit Exercise (p.91)

PART I KNOWLEDGE AND UNDERSTANDING

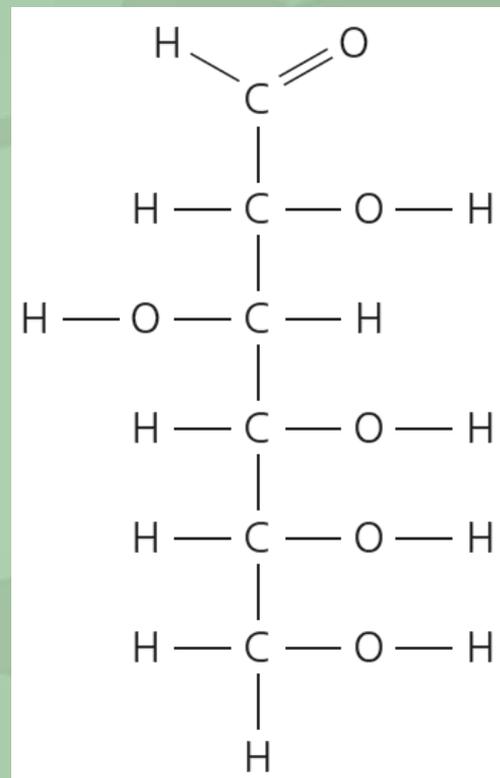
1 Complete the following concept map.

- a) $-\text{CH}_2-$
- b) physical
- c) chemical
- d) $\text{C}_n\text{H}_{2n+2}$
- e) C_nH_{2n}
- f) $\text{C}_n\text{H}_{2n+1}\text{OH}$
- g) $\text{C}_n\text{H}_{2n+1}\text{COOH}$



 Unit Exercise (p.91)**PART II MULTIPLE CHOICE QUESTIONS**

2 The structural formula of glucose is shown below.



What is the empirical formula of glucose?

- A CH_2O
- B CH_3O
- C $\text{C}_3\text{H}_8\text{O}_3$
- D $\text{C}_6\text{H}_{12}\text{O}_6$

Answer: A

Explanation:

The molecular formula of glucose is $\text{C}_6\text{H}_{12}\text{O}_6$.

Unit Exercise (p.91)

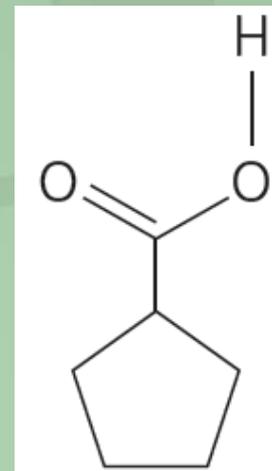
3 The skeletal formula of a compound is shown below.



What is the molecular formula of the compound?

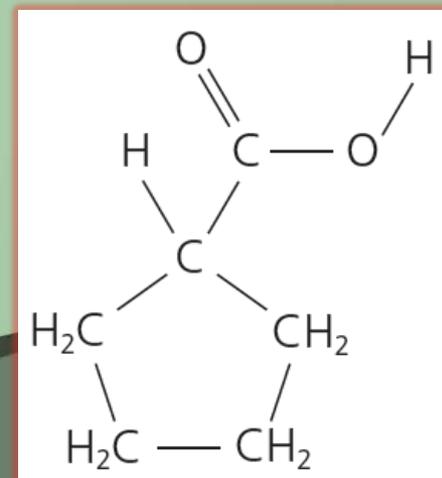
- A $C_5H_8O_2$
- B $C_5H_9O_2$
- C $C_6H_9O_2$
- D $C_6H_{10}O_2$

Answer: D



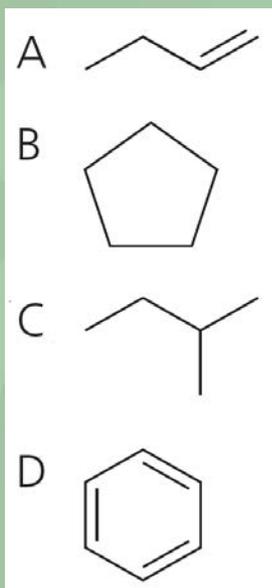
Explanation:

The structural formula of the compound is shown below.
The molecular formula of this compound is $C_6H_{10}O_2$.



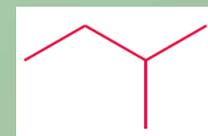
 Unit Exercise (p.91)

4 Which of the following compounds has the same molecular formula and empirical formula?

Explanation:
The molecular formula and empirical formula of
are both C_5H_{12} .

Answer: C



 Unit Exercise (p.91)

5 Which of the following molecular formulae can represent an alkanoic acid?

- A CH_2O
- B $\text{C}_2\text{H}_6\text{O}_2$
- C $\text{C}_4\text{H}_8\text{O}_2$
- D $\text{C}_4\text{H}_{10}\text{O}_2$

Answer: C

(HKDSE, Paper 1A, 2018, 8)

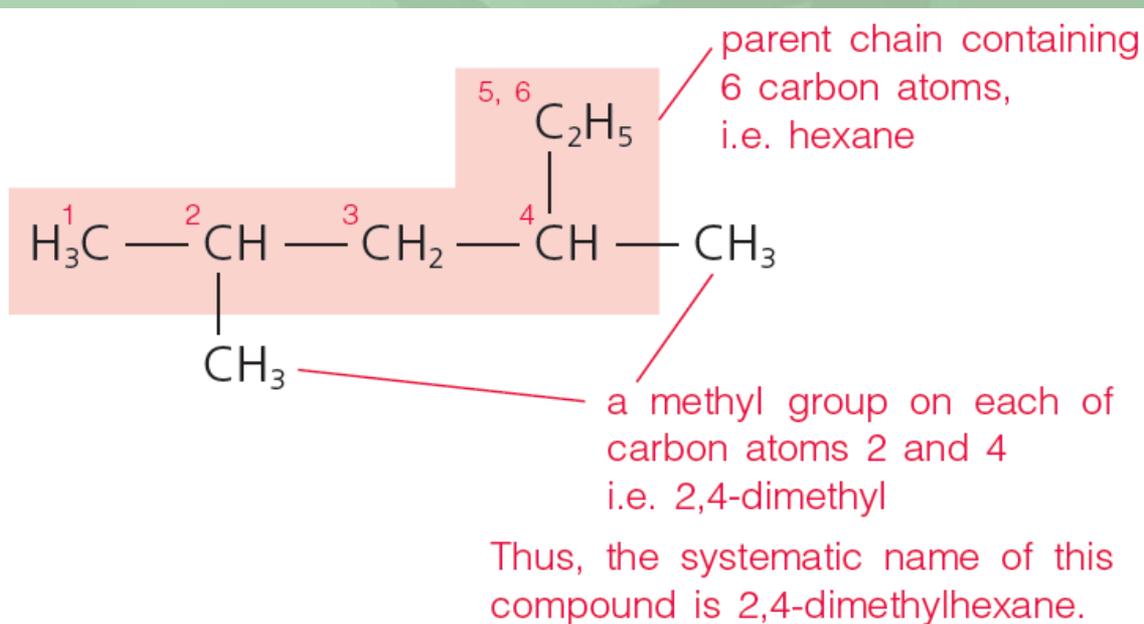
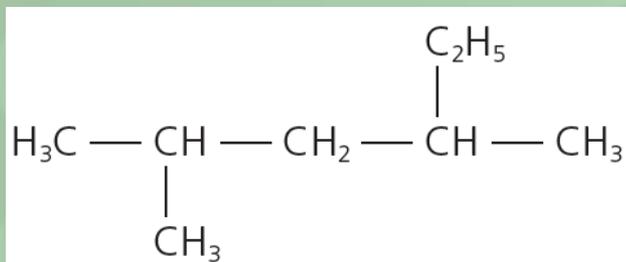


Unit Exercise (p.91)

6 What is the systematic name for the compound with the following formula?



Answer: C



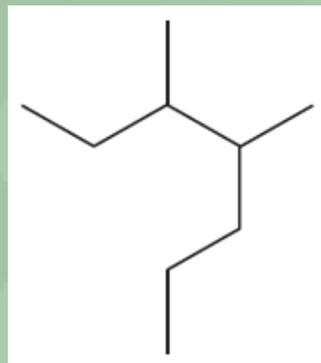
- A 2-methyl-4-ethylpentane
- B 2-ethyl-4-methylpentane
- C 2,4-dimethylhexane
- D 3,5-dimethylhexane

(Edexcel Advanced Subsidiary GCE Unit 1, Jun. 2015, 2)



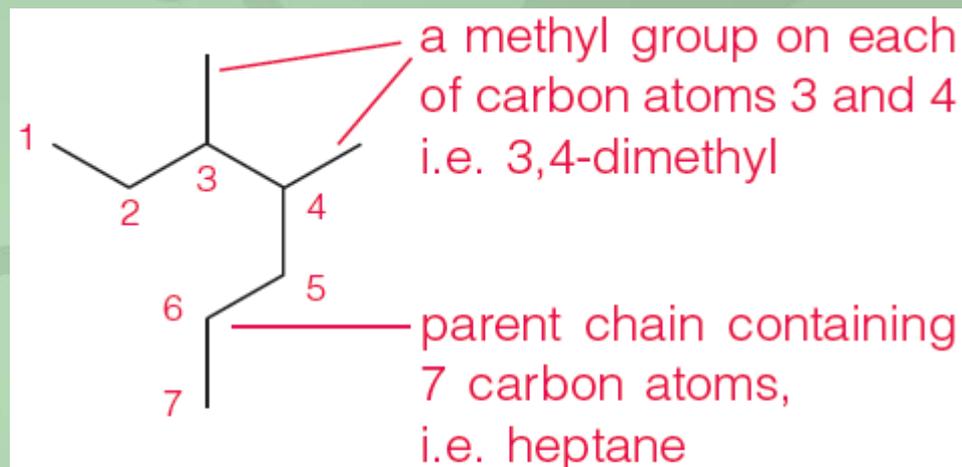
Unit Exercise (p.91)

7 What is the systematic name of the following?



- A 3-methyl-2-propylpentane
- B 3-methyl-4-propylpentane
- C 3,4-dimethylheptane
- D 4,5-dimethylheptane

Answer: C



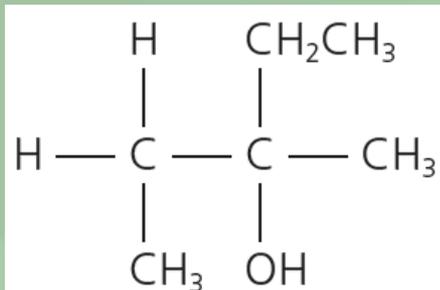
Thus, the systematic name of this compound is 3,4-dimethylheptane.

(Edexcel Advanced Subsidiary GCE, Unit 1, Jun. 2016, 14)



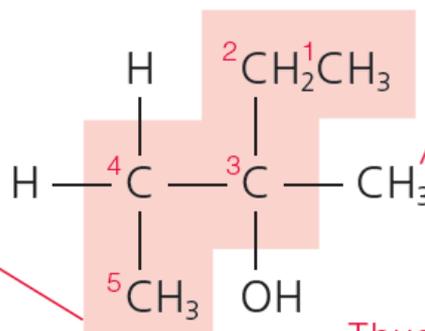
Unit Exercise (p.91)

8 The structural formula of compound R is shown below.



Answer: D

parent chain containing 5 carbon atoms, with the -O-H group on carbon atom 3, i.e., pentan-3-ol



a methyl group on carbon atom 3, i.e. 3-methyl

Thus, the systematic name of this compound is 3-methylpentan-3-ol.

The systematic name of R is

- A 2-ethyl-3-methylpropan-2-ol.
- B 2-ethylbutan-2-ol.
- C 3-ethylbutan-3-ol.
- D 3-methylpentan-3-ol.

 Unit Exercise (p.91)

9 What is the systematic name of $\text{Cl}_2\text{CH}-\text{CH}=\text{CH}-\text{CH}=\text{CH}_2$?



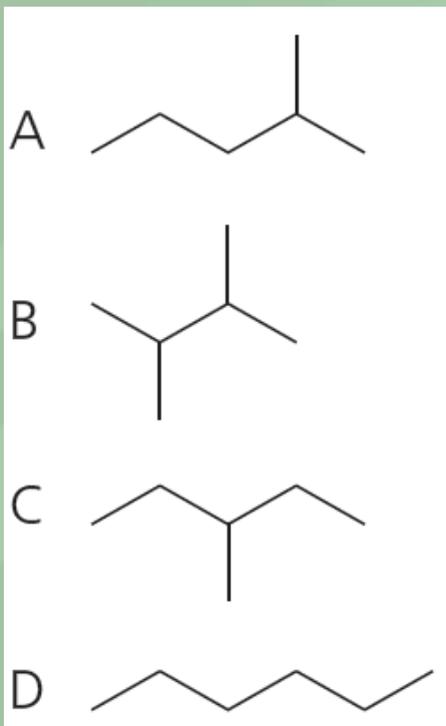
- A 1-dichloropenta-2,4-diene
- B 5,5-chloropenta-1,3-diene
- C 1,1-dichloropenta-2,4-diene
- D 5,5-dichloropenta-1,3-diene

Answer: D

(HKDSE, Paper 1A, 2017, 5)

 Unit Exercise (p.91)

10 Which of the following compounds has the highest melting temperature?



Answer: D

Explanation:

Among the molecules,  is the longest and spreadout most. The molecule has the largest surface area, allowing the greatest surface of contact with neighbouring molecules.

Thus, the van der Waals' forces among molecules are the strongest.



(Edexcel Advanced Subsidiary GCE, Unit 2, Jun. 2014, 4)

 Unit Exercise (p.91)

11 Which of the following statements concerning methylpropane is INCORRECT?



- A It is a saturated hydrocarbon.
- B It is soluble in water
- C Its molecular formula is C_4H_{10} .
- D Its boiling point is lower than that of butane.

Answer: B

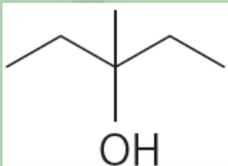


Unit Exercise (p.91)

12 The structural formula of compound X is shown below.



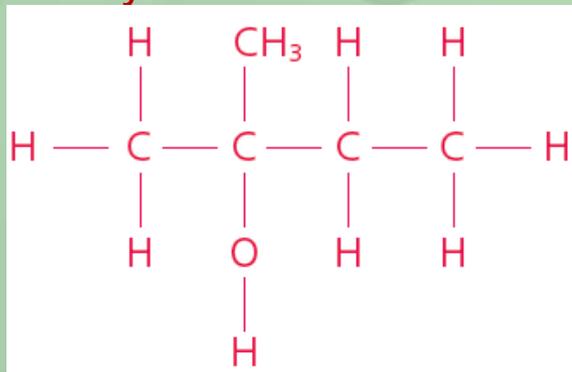
Which of the following statements about compound X is correct?

- A Its systematic name is methylbutanol.
- B It contains a carboxyl functional group.
- C Its general formula is $\text{C}_n\text{H}_{2n+1}\text{OH}$.
- D Its skeletal formula is 

Answer: C

Explanation:

Option A — The systematic name of the compound is 2-methylbutan-2-ol.



Option C — The compound is an alkanol. Its general formula is $\text{C}_n\text{H}_{2n+1}\text{OH}$.



Unit Exercise (p.91)

13 Which of the following are characteristics exhibited by members of a homologous series?

- (1) They have similar chemical properties.
- (2) They display a gradation in physical properties.
- (3) They can be represented by the same general formula.

- A (1) and (2) only
- B (1) and (3) only
- C (2) and (3) only
- D (1), (2) and (3)

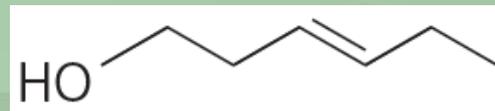
Answer: D

(HKDSE, Paper 1A, 2017, 20)



Unit Exercise (p.91)

14 Compound X shown below has a strong 'leafy' smell of newly cut grass.



Which of the following statements about compound X are correct?

- (1) Its molecular formula is $C_6H_{12}O$.
- (2) It contains a hydroxyl group.
- (3) Its systematic name is hept-4-en-1-ol

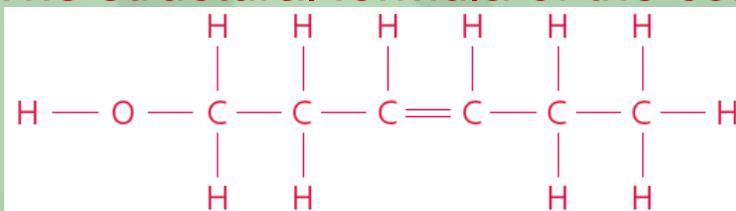
Answer: A

A (1) and (2) only **Explanation:**

B (1) and (3) only (1) The structural formula of the compound is as shown:

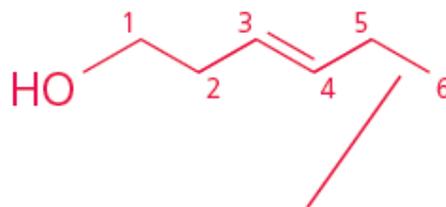
C (2) and (3) only

D (1), (2) and (3)



Its molecular formula is $C_6H_{12}O$.

(3)



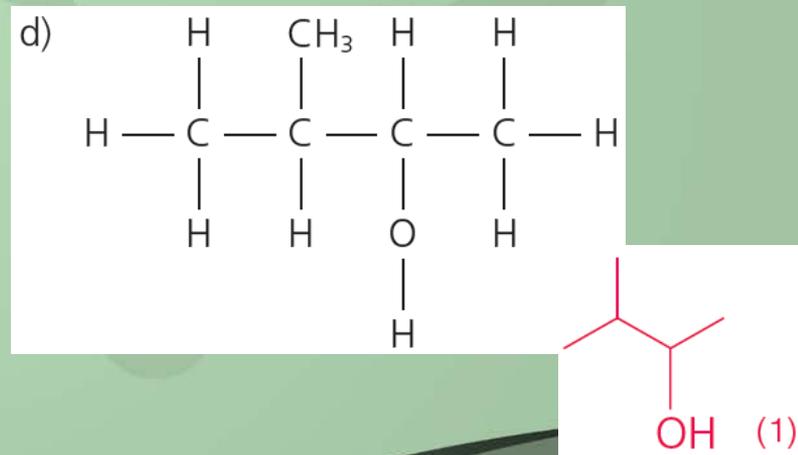
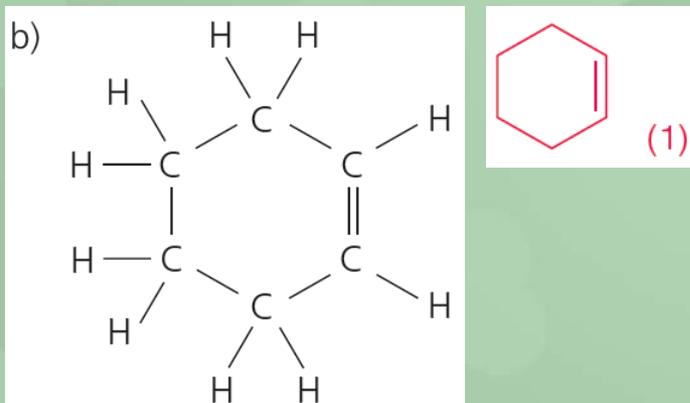
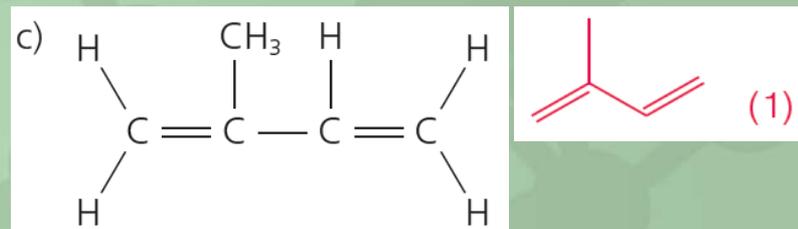
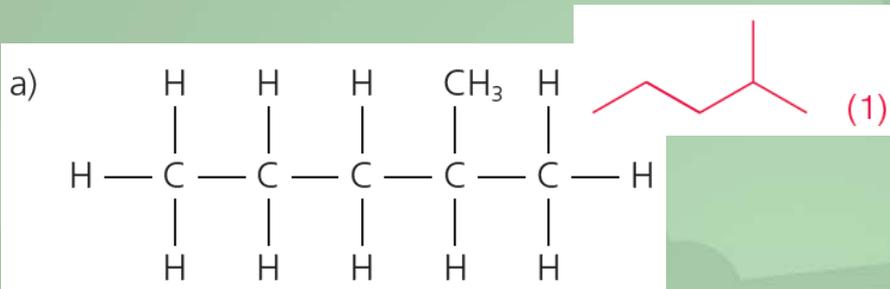
parent chain containing 6 carbon atoms, with the $-O-H$ group on carbon atom 1, and the double bond between carbon atoms 3 and 4, i.e. hex-3-en-1-ol.



Unit Exercise (p.91)

PART III STRUCTURED QUESTIONS

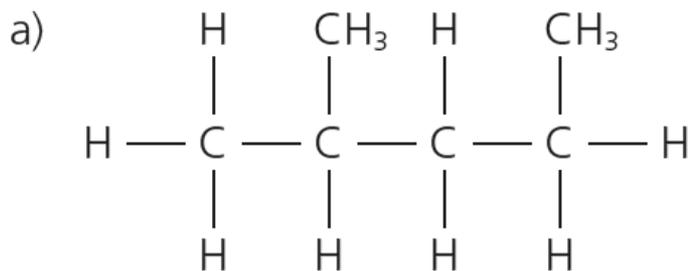
15 Write the skeletal formulae of the following compounds.



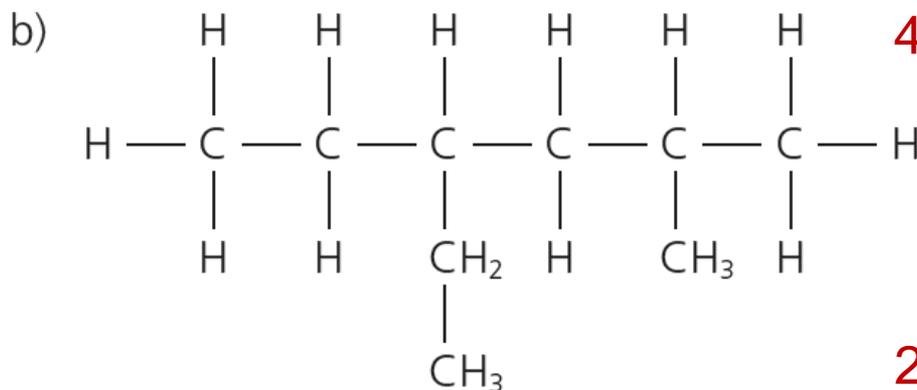


Unit Exercise (p.91)

16 Give the systematic names of the compounds below.



2-methylpentane (1)



4-ethyl-2-methylhexane (1)



2,2-dimethylpentane (1)

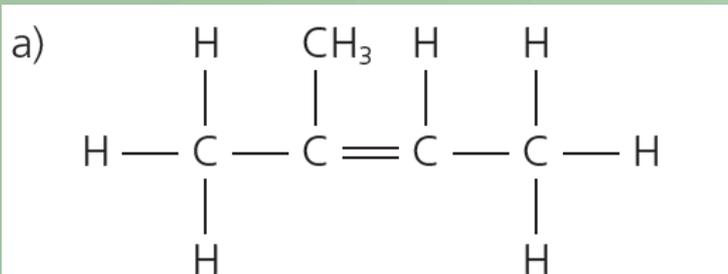


dimethylpropane (1)

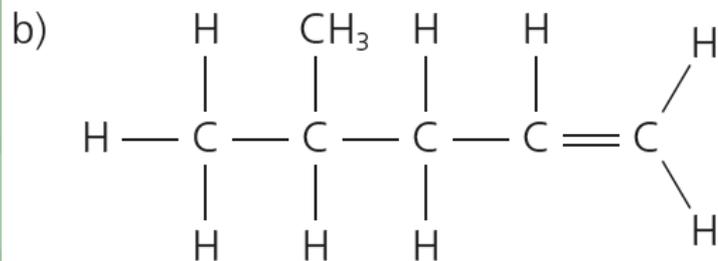


Unit Exercise (p.91)

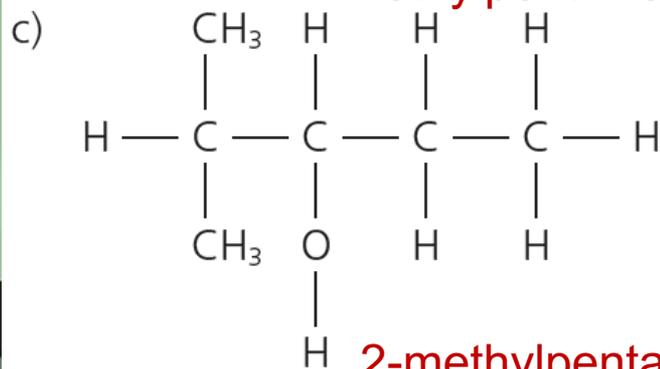
17 Give the systematic names of the compounds below.



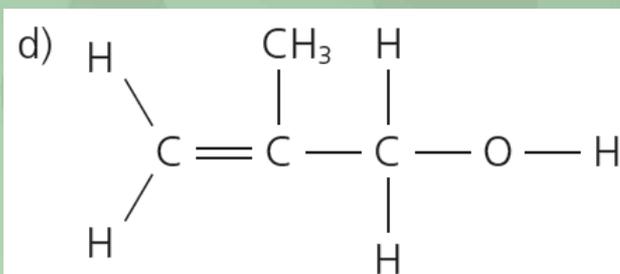
2-methylbut-2-ene (1)



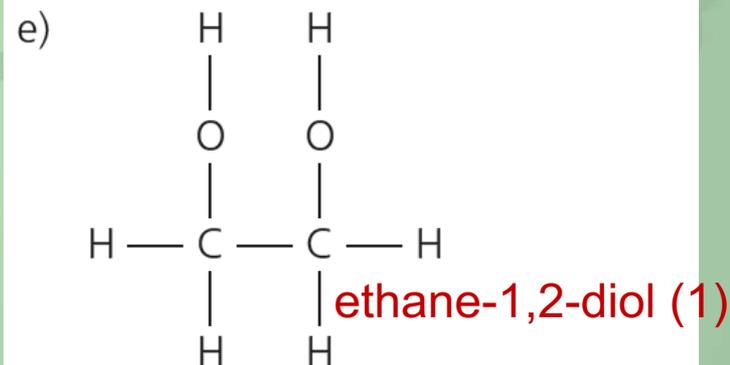
4-methylpent-1-ene (1)



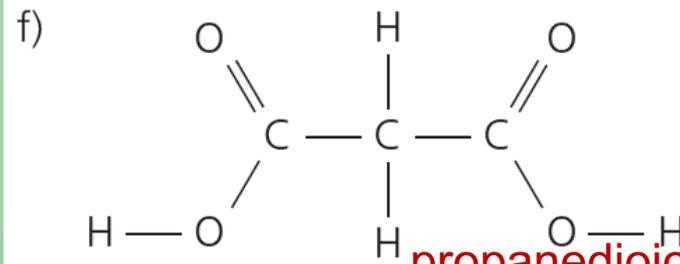
2-methylpentan-3-ol (1)



2-methylprop-2-en-1-ol (1)



ethane-1,2-diol (1)



propanedioic acid (1)



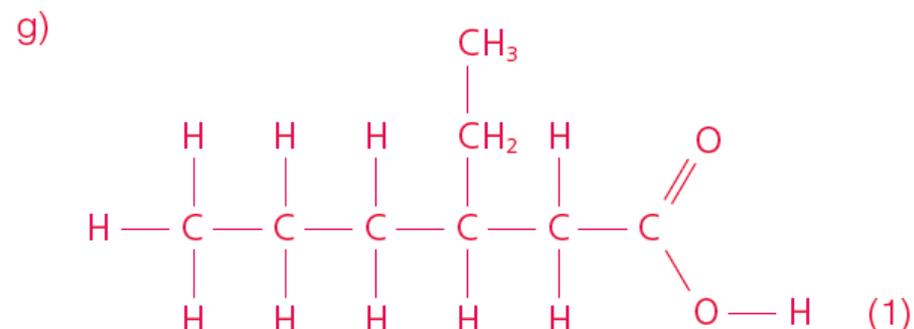
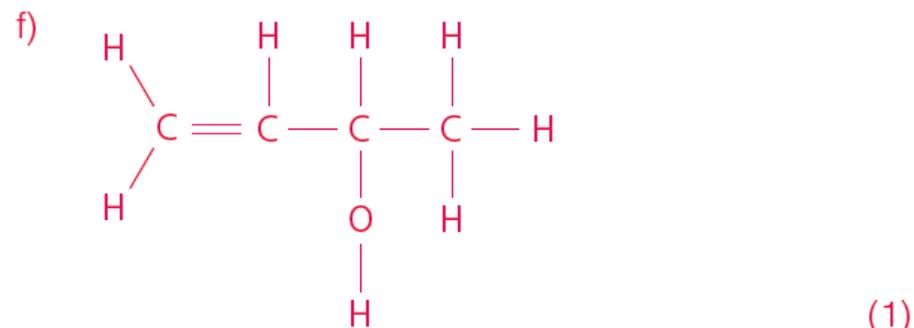
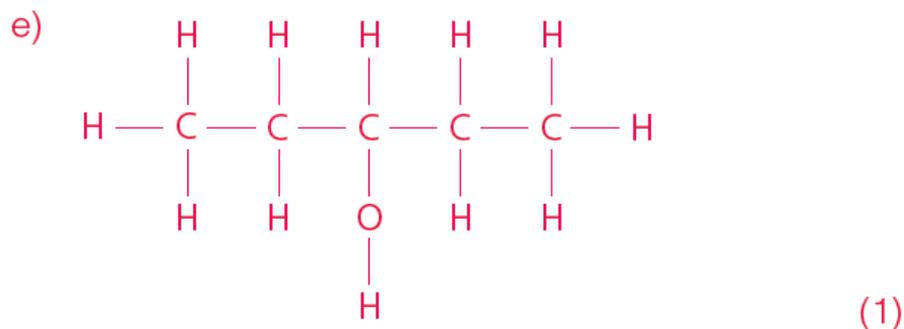
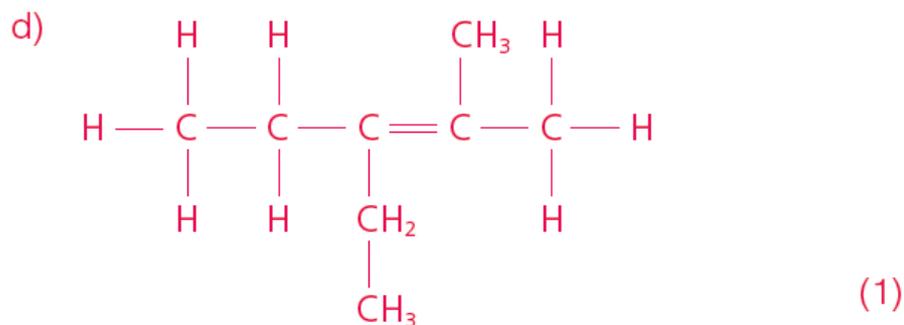
Unit Exercise (p.91)

d) 3-ethyl-2-methylpent-2-ene

e) pentan-3-ol

f) but-3-en-2-ol

g) 3-ethylhexanoic acid



 Unit Exercise (p.91)

19 The table below lists the names, numbers of carbon atoms per molecule and molecular formulae of some alkanes.

Alkane	Number of carbon atoms per molecule	Molecular formula
Methane	1	CH ₄
Ethane	2	C ₂ H ₆
Pentane	5	C ₅ H ₁₂
Hexane	6	C ₆ H ₁₄

a) What is the name of the alkane in the table which has the empirical formula CH₃? Explain your answer.

Ethane (1)

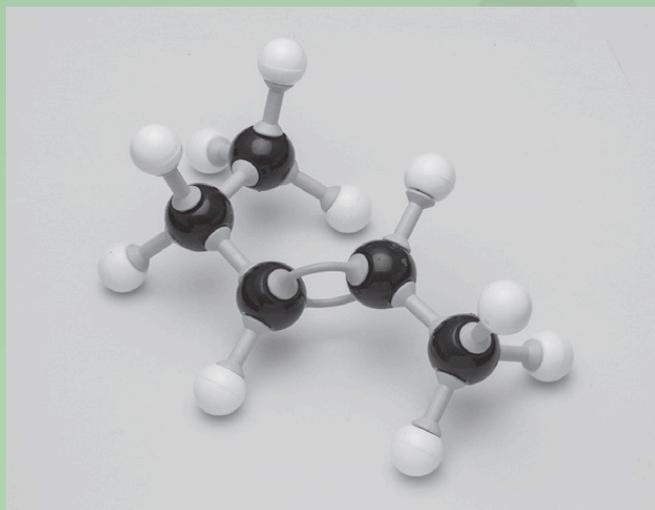
The ratio of C : H is 2 : 6. (1)

Thus, the simplest whole number ratio of C : H is 1 : 3.



Unit Exercise (p.91)

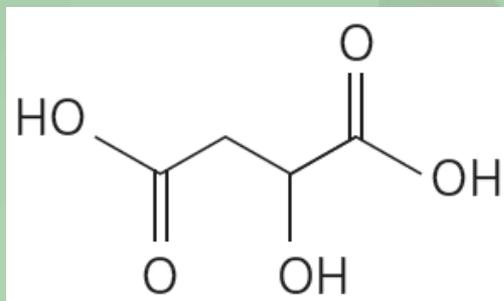
b) The diagram shows a ball-and-stick model of a hydrocarbon.



- i) Give the molecular formula and the systematic name of this hydrocarbon. C_5H_{10} (1)
Pent-2-ene (1)
- ii) To which homologous series does this hydrocarbon belong?
Alkenes (1)
- iii) What is the general formula of this homologous series?
 C_nH_{2n} (1)

 Unit Exercise (p.91)

 20 One of the acids found in apple juice is malic acid. The skeletal formula of malic acid is shown below.

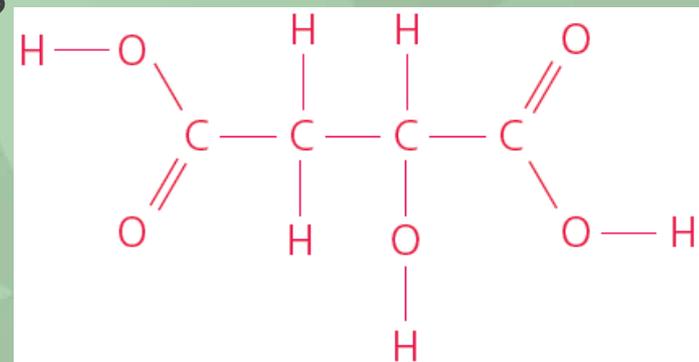


a) What is the molecular formula of malic acid?

The structural formula of malic acid is as shown.

The molecular formula of malic acid is

C₄H₆O₅. (1)



b) Name ALL the functional groups found in malic acid.

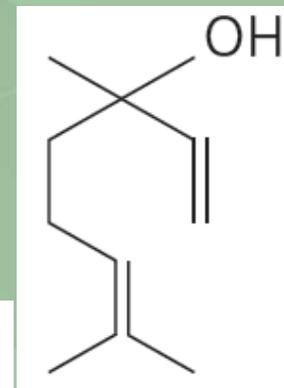
Carboxy group (1)

Hydroxyl group (1)



Unit Exercise (p.91)

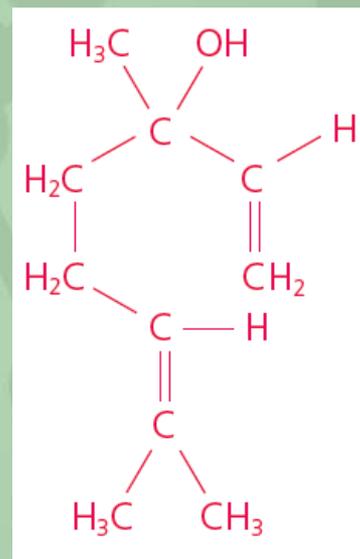
21 Linalool is a compound found in the seeds of the coriander plant. The skeletal formula of linalool is shown below.



a) What is the molecular formula of linalool?

The structural formula of linalool is as shown.

The molecular formula of linalool is $C_{10}H_{18}O$. (1)



b) Linalool is an unsaturated compound.

What feature in the formula of linalool shows that it is an unsaturated compound? **It contains carbon-carbon double bonds** (1)

 Unit Exercise (p.91)

22 The boiling points of five hydrocarbons are listed in the table below.



Hydrocarbon	Methane CH ₄	Ethane CH ₃ CH ₃	Propane CH ₃ CH ₂ CH ₃	Butane CH ₃ CH ₂ CH ₂ CH ₃	Pentane CH ₃ CH ₂ CH ₂ CH ₂ CH ₃
Boiling point (K)	111	184	231	273	309

- a) State a process used to separate a hydrocarbon from a mixture of these hydrocarbons. **Fractional distillation (1)**
- b) To which homologous series do these hydrocarbons belong? **Alkanes (1)**
- c) What is the general formula of this homologous series? **C_nH_{2n+2} (1)**
- d) Both propane and butane can be liquefied and used as fuels for camping stoves.

Suggest, with ONE reason, which of these two fuels is liquefied more easily. **Butane liquefied more easily.**

Butane has a higher boiling point / stronger intermolecular forces / larger molecules. (1)



Unit Exercise (p.91)

23 The alkanes form a homologous series of hydrocarbons. The table below lists information of some straight-chain alkanes.



Number of carbon atoms per molecule	Molecular formula of alkane	Boiling point (°C)	Relative viscosity at 25 °C
6	C_6H_{14}	69	0.29
7	C_7H_{16}	98	0.39
8	C_8H_{18}	126	0.51
10	$C_{10}H_{22}$?	0.85
12	$C_{12}H_{26}$	214	1.36
14	?	255	2.08

 Unit Exercise (p.91)

a) Deduce the molecular formula of an alkane with 14 carbon atoms per molecule. $C_{14}H_{30}$ (1)

b) Alkanes have the same general formula.

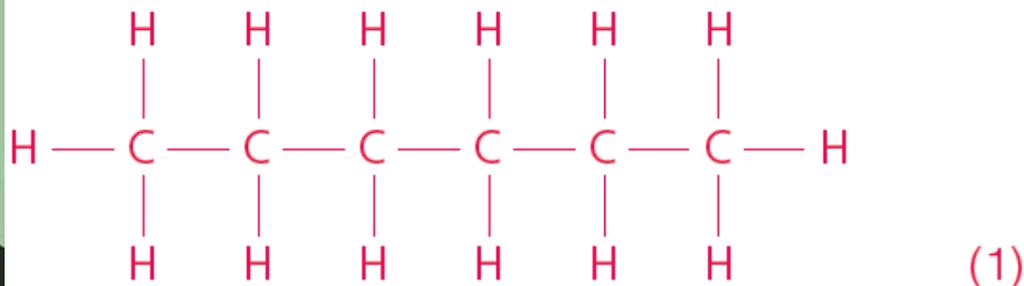
Other than having the same general formula, state TWO other characteristics of members of the same homologous series.

Any two of the following:

Members

- differ from the next by a $-CH_2-$ unit. (1)
- have similar chemical properties. (1)
- have physical properties showing a trend. (1)

c) Write the structural formula of the straight-chain alkane C_6H_{14} .



 Unit Exercise (p.91)

d) Deduce the boiling point of the straight-chain alkane $C_{10}H_{22}$.

About $170\text{ }^{\circ}\text{C}$ (the actual value is $174\text{ }^{\circ}\text{C}$) (1)

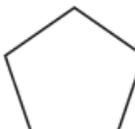
e) Describe and explain the relationship between the viscosities of straight-chain alkanes and the sizes of their molecules.

The larger the size of molecule of a straight-chain alkane, the higher the viscosity of the alkane is. (1)

The larger the molecule size of a straight-chain alkane, the stronger the van der Waals' forces among the molecules are. (1)

 Unit Exercise (p.91)

24  This question is about cyclic organic compounds. The table shows some information about cycloalkanes.

Cycloalkane	Skeletal formula	Boiling point (°C)
Cyclopropane		-33
Cyclopentane		49
Cyclohexane		81

 Unit Exercise (p.91)

These cycloalkanes are members of the same homologous series and have the same general formula.

a) What is meant by the term 'homologous series'?

A 'family' of compounds that have a common functional group, with each successive member differing by a -CH₂- unit, is called a homologous series. (1)

b) State the general formula for these cycloalkanes.



c) Explain the increase in boiling points of the cycloalkanes shown in the table.

The molecular size increases from cyclopropane to cyclohexane. (1)

Thus, the strength of van der Waals' forces among molecules increases from cyclopropane to cyclohexane. (1)

(OCR Advanced Subsidiary GCE, Chem. A, F322, Jun. 2014, 1)



Unit Exercise (p.91)

25 Dodec-1-ene is an alkene with 12 carbon atoms per molecule.



a) What is the molecular formula of dodec-1-ene?

$C_{12}H_{24}$ (1)

b) Name the functional group of dodec-1-ene.

Carbon-carbon double bond (1)

c) Explain why dodec-1-ene is a liquid at room temperature whereas ethene is a gas.

A dodec-1-ene molecule has a greater size than an ethene molecule. (1)

Thus, the van der Waals' forces among dodec-1-ene molecules are stronger than those among ethene molecules. (1)



Unit Exercise (p.91)

d) Suggest and explain whether dodec-1-ene is soluble in water.

Dodec-1-ene is insoluble in water.

When dodec-1-ene is added to water, there is little interaction between molecules of dodec-1-ene and water. (1)

The attractive forces among water molecules are strong. The attractive forces between dodec-1-ene molecules and water molecules are weaker in comparison. (1)

Thus, water molecules tend to stick together, rather than allowing dodec-1-ene molecules to come between them. As a result, dodec-1-ene molecules and water molecules do not mix easily. (1)