Higher Chemistry

Topic 5:

Organic 1

Study Guide 1

Systematic Organic in Context

SYSTEMATIC ORGANIC IN CONTEXT 5.1

⦿ *Introduction*

The study of Organic Chemistry - Nature's Chemistry - can appear bewilderingly diverse given the wide variety of carbon based molecules found everywhere in nature along with the explosion of man-made molecules in recent years. A systematic approach is essential.

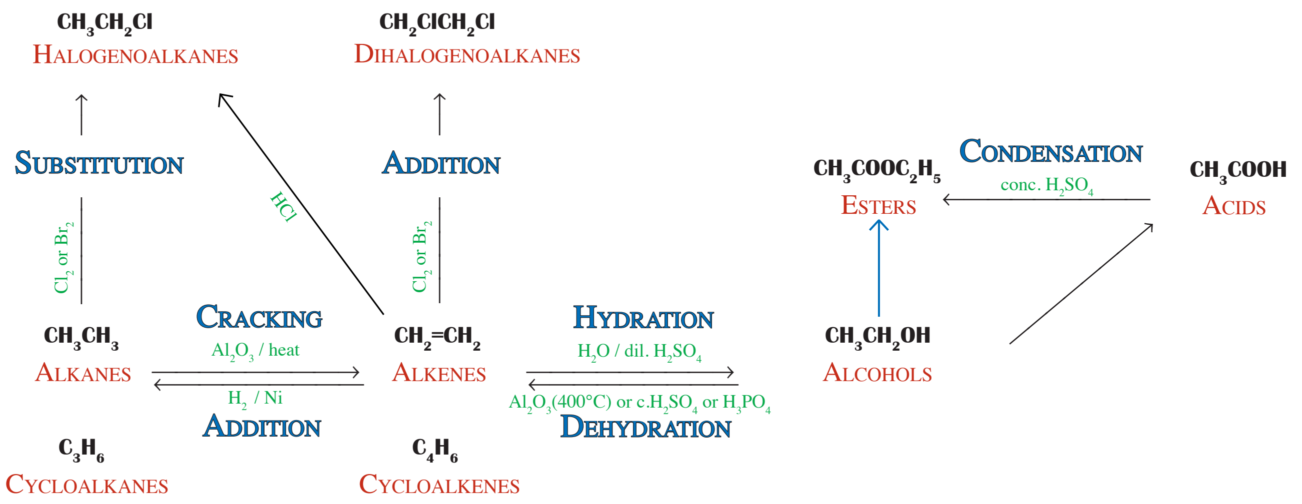
At the same time, it is important to look beyond the academic study and place these molecules firmly within their contexts and applications.

This first lesson topic takes an overview of the Organic reactions met in this and previous courses and some of the contexts in which these reactions are met. Later lessons will deal with the detail.

① *Previous Chemistry*

Most of the Organic Chemistry met previously involved the various hydrocarbon families as well as alcohols, acids and esters.

This activity examines the systematic approach to the reactions met in previous courses.



There are 4 aspects to the Systematic approach to Organic Chemistry, and you should try to master all 4 aspects:

- ***Names*** of both reactant molecule and product molecule (***RULES !***)
- ***Structures*** of both reactant molecule and product molecule
- ***Title*** of the reaction
- ***Reagents*** used to carry out the reaction

Think

Think about the Reaction Pathways diagram above

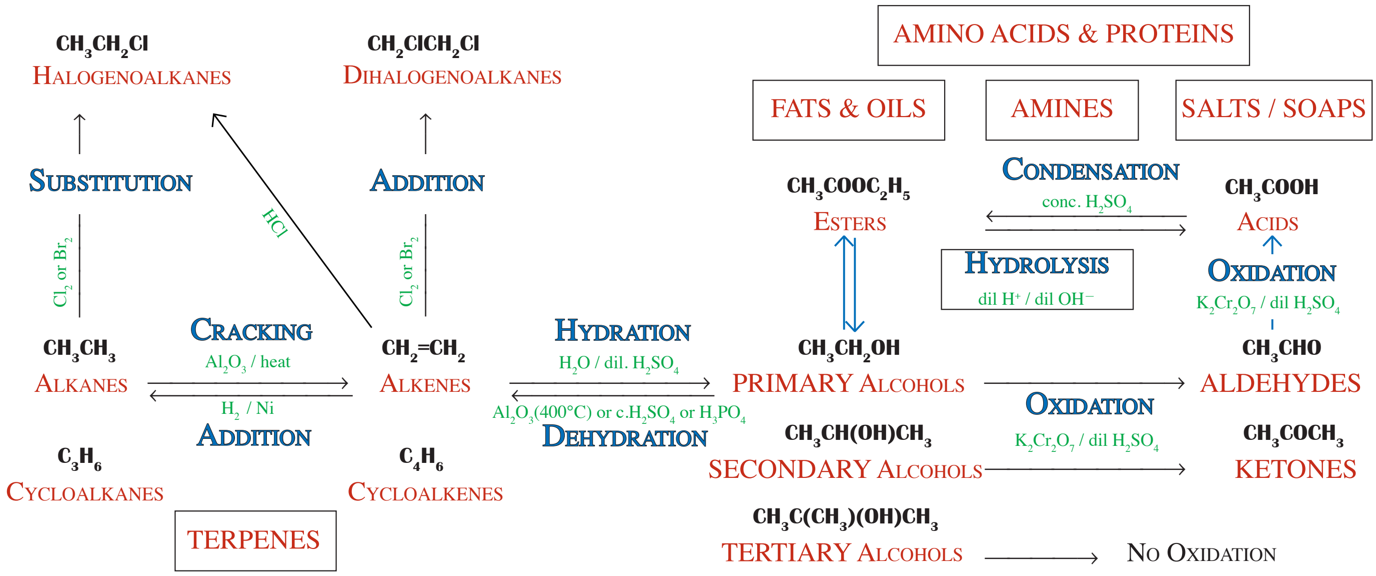
- What is the main difference between ***Substitution*** and ***Addition***?
- Molecules can be described as ***Saturated*** or ***Unsaturated***. What do these words mean and which type of reaction goes with each?
- What other ***Title*** can be given to the ***Hydration*** reaction?
- What do ***Condensation*** and ***Dehydration*** have in common? What is the important difference between these reactions?

Notes

② *New Chemistry*

During the Higher course you will be asked to add to the Organic Chemistry met previously.

This activity looks at some of the new reactions / families that you will meet in this Unit.



Much of the new Chemistry revolves round learning the ***Oxidation*** reaction in more detail. As can be seen, there are 3 types of ***Alcohols*** to be learnt and they produce different products - ***Aldehydes*** or ***Ketones***, or none - when oxidised. ***Aldehydes*** are the intermediates formed when a ***Primary Alcohol*** is oxidised to eventually form an ***Acid***.

Condensation becomes even more important - along with the reverse reaction, ***Hydrolysis***. Not just ***Esters*** are formed by a ***Condensation*** reaction - ***Proteins*** and ***Fats & Oils*** are also formed by ***Condensation*** and broken down by the ***Hydrolysis*** reaction. ***Soaps*** are the ***Salts*** of *Fatty Acids* formed when ***Alkali Hydrolysis*** is done to a ***Fat*** or ***Oil***.

Terpenes are natural *hydrocarbons*, found mainly in plants, formed by joining together smaller molecules called ***isoprene***, *2-methylbuta-1,3-diene*. ***Terpenes*** belong to a group of chemicals usually referred to as *essential oils* which should not be mixed up with *edible oils* (***Fats & Oils***) and *mineral oils* derived from *Crude Oil* and made by the *Petrochemical* industry.

Think

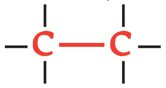
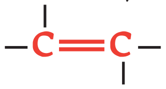
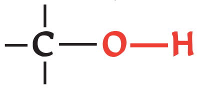
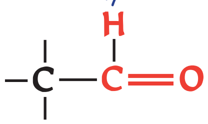
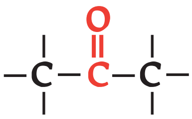
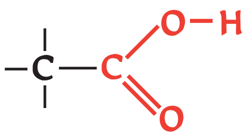
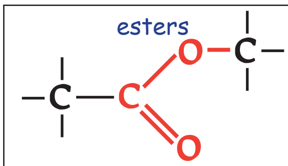
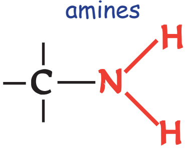
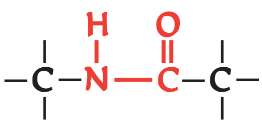
Think about the Reaction Pathways diagram above and the information given.

- What makes an alcohol *primary*, *secondary* or *tertiary*? (***Hint:*** draw the full structures of the 3 examples given.)
- What feature is common to both ***aldehydes*** and ***ketones***? (***Hint:*** draw the full structures of the 2 examples given.)
- What is the meaning of the word *electrolysis*? What does ***hydrolysis*** mean?
- ***Proteins*** are formed by the ***Condensation Polymerisation*** of ***amino acids***. Which is the *monomer* and which is the *polymer*?
- ***Fats & Oils*** are formed by a ***condensation*** reaction involving the ***alcohol***, *glycerol*, and 3 *fatty acid* molecules. Are they also *polymers*?

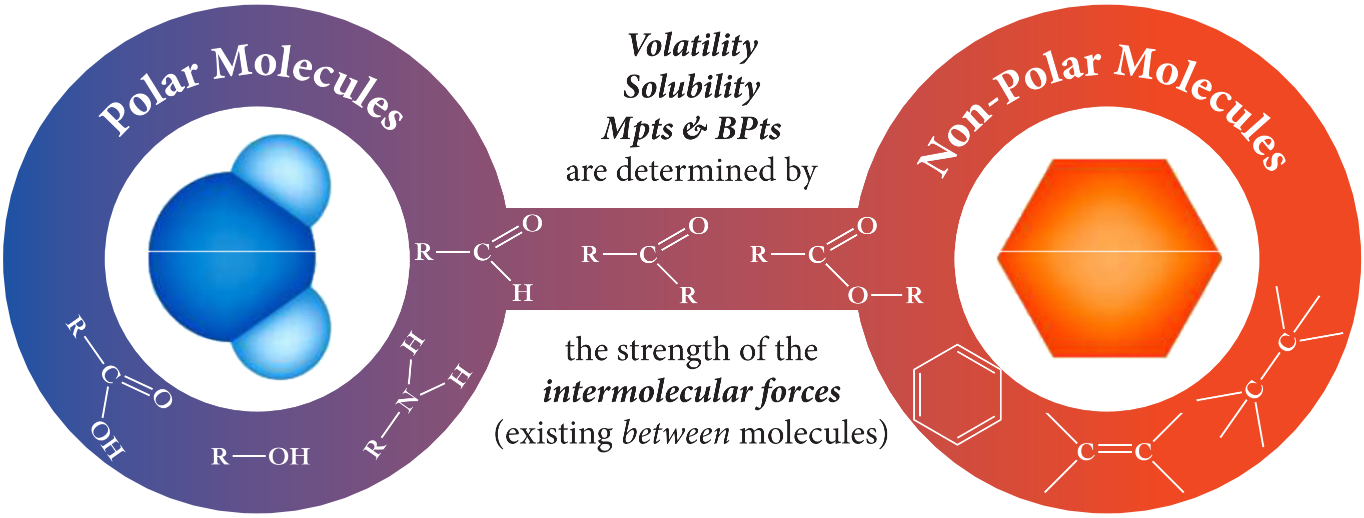
Notes

③ *Functional Groups & Properties*

This activity explains the functional groups found in these molecules and their possible effect on the chemical and physical properties of the molecule.

saturated, alkanes  carbon to carbon single	*least reactive* - ***substitution*** reactions mainly *zero polarity* - ***london dispersion forces*** only - *insoluble in water*
unsaturated, alkenes  carbon to carbon double	*more reactive* - ***addition*** reactions mainly *very slight polarity* - ***london dispersion forces*** only - *insoluble in water*
alcohols  hydroxyl group	*reactive* - ***oxidation*** and ***condensation*** reactions mainly *very polar* - ***hydrogen bonding*** - *very soluble in water*
aldehydes  carbonyl group	*not very reactive* - ***oxidation*** reaction (*addition* also possible at ***ADVH***) *reasonably polar* - ***polar-polar*** *(permanent dipole)* attractions by itself, but can do ***hydrogen bonding*** with water - *so reasonably soluble in water*
ketones  carbonyl group	*not reactive* - ***no oxidation*** reaction (*addition* possible at ***ADVH***) *reasonably polar* - ***polar-polar*** *(permanent dipole)* attractions by itself, but can do ***hydrogen bonding*** with water - *so some solubility in water*
acids  carboxyl group	*reactive* - ***condensation*** reaction - with *alcohols* to form *esters* - with *amines* to form *amides* *very polar* - ***hydrogen bonding*** - *very soluble in water and can ionise to produce* $H^+_{(aq)}$ *ions* - ***acid reactions***
esters  carboxylate group	*not reactive* - ***hydrolysis*** reaction only - to reform *alcohols* and *acids* *slight polarity* - ***polar-polar*** *(permanent dipole)* attractions by itself, - *so usually insoluble in water*
amines  amino group	*reactive* - ***condensation*** reaction - with *acids* to form *amides* *very polar* - ***hydrogen bonding*** - *very soluble in water and can ionise to produce* $OH^-_{(aq)}$ *ions* - ***like ammonia***
amide  amide link	*not reactive* - ***hydrolysis*** reaction only - to reform *acids* and *amines* *very polar* - ***hydrogen bonding*** *still possible in proteins which plays an important role in structure and properties but molecules too big to be soluble in water.*

Though we will be concentrating on learning the *Chemical Reactions* involving organic molecules, the *Physical Properties* are equally important. Properties such as

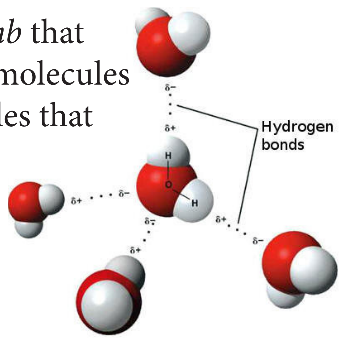


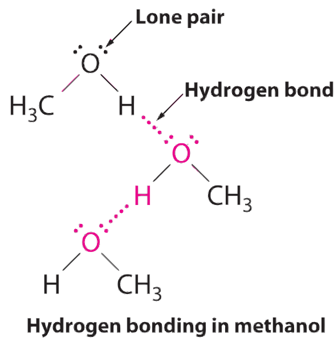
hydrogen bonding → ***polar-polar attractions*** → ***london dispersion***

Acids Alcohols Amines	***Aldehydes Ketones Esters***	***Aromatics Alkenes Alkanes***

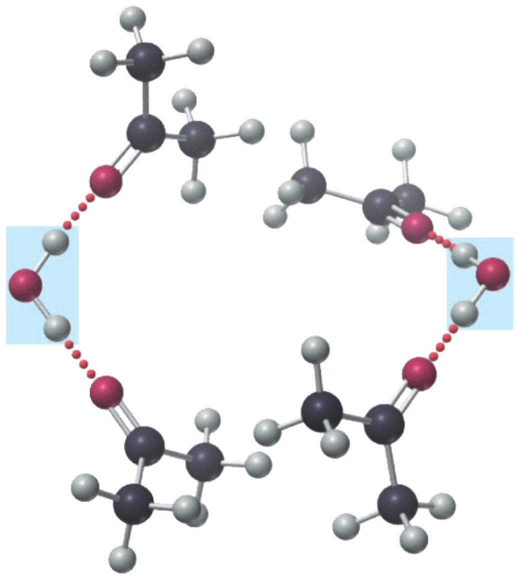
In general, we use the *Rule of Thumb* that '***like dissolves like***' - meaning that molecules will mix/dissolve best with molecules that have similar ***intermolecular forces***.

To be soluble in water, a molecule must *either* already have ***hydrogen bonding*** - like *acids*, *alcohols* and *amines*,





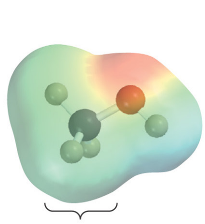
or,



be capable of setting up ***hydrogen bonding*** with water molecules - some *aldehydes* and *ketones* are capable of doing this.

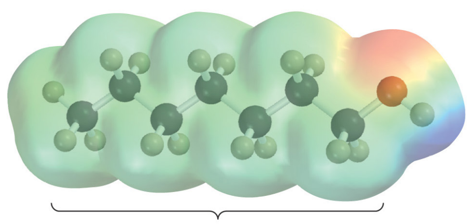
Solubility will decrease, however, as *chain length increases*. due to the *increasing role of* ***london dispersion forces*** between molecules.

CH_3—OH



Methanol: has a small organic part and is therefore water-like.

$CH_3CH_2CH_2CH_2CH_2CH_2CH_2$—OH



1-Heptanol: has a large organic part and is therefore alkane-like.

As is often the case with Chemistry, *practical experiments* - mixing chemicals to see if they mix/dissolve - are much more reliable than predictions based on the structure of a molecule though ***you will be asked to make these predictions.***

Notes

④ *Context - Kitchen Chemistry*

This activity demonstrates how much of the Organic Chemistry met in this Unit will be taught within the context of Kitchen Chemistry

Flavour

Most of our 'tasting' is done through our noses, so most flavour molecules are *volatile* (*weak intermolecular forces*) such as

esters - many have sweet fruity smells - e.g. '*pear drops*' - *pentyl ethanoate*
aldehydes - can however be ***oxidised*** over time resulting in (sometimes unpleasant) changes in flavour
terpenes - '*essential oils*' are responsible for many distinctive flavours such as *cinnamon* and *ginger* as well as *oranges* and *lemons*.
acids - such as *vinegar*, *ethanoic acid* are used to introduce 'sour' flavours

Cooking

Cooking can *dissolve* out the flavour molecules so whilst many foods can be safely *cooked in water,* others are better *cooked in oil*.

Cooking also effects the structure of, in particular, ***proteins*** which can result in significant change in the *texture* of certain foods during cooking.

Texture

Protein *structure* has an important impact on the *texture* of food and can be effected by *changes in temperature* (*cooking*) and *changes in pH* (*marinading* in ***acids*** such as *vinegar*, *ethanoic acid*).

Foods, such as curries, often '*separate*' into '*water layer*' and '*oil layer*' as a result of *differences in solubility* (*different intermolecular forces*).

Colour

Colour can arise in many ways but larger ***terpenes*** are often responsible for the *yellow*, *orange* or *red* colour of so many foods - e.g. *carotene* in carrots.

Energy

Whilst ***carbohydrates,*** our main '*energy food*', are not covered in this course, ***proteins*** also contribute energy whilst *fats & oils* are our most concentrated source of energy.

Additives

antioxidants - can be added to food, though many foods already contain *Vitamin C* - a natural *antioxidant*

emulsifying agents - are used to prevent '*water layers*' and '*oily layers*' from separating. These molecules are often made from ***fats & oils*** and behave in exactly the same way as *soap molecules*. *Milk* contains natural ***emulsifiers***.

In addition, many reactions triggered by *UV light*, such as the ***substitution*** reaction between *alkanes* and *bromine*, involve the production of ***free radicals***. ***Free radicals*** start ***chain reactions*** which are responsible for the ageing of your skin. *Sun cream* contains chemicals designed to absorb UV before it reaches your skin.

Vitamin E and *melatonin* are natural ***free radical scavengers*** that can help counter the effect of free radicals. Many ***cosmetic*** products contain *free radical scavengers* which react with ***free radicals*** to form stable molecules and prevent ***chain-reactions*** starting.

Notes

CHECK TEST 5.1

Q1. Which of the following hydrocarbons does not belong to the same homologous series as the others?

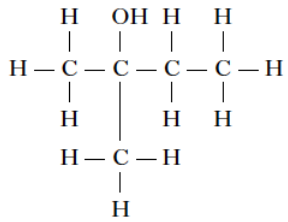
A CH_4

B C_3H_8

C C_4H_{10}

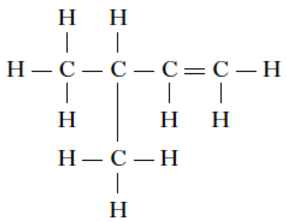
D C_6H_{12}

Q2.



The above compound could be formed by adding water to

A



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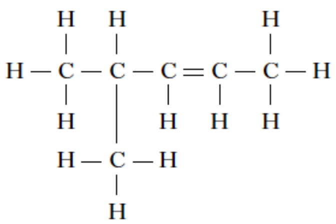
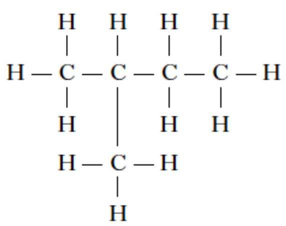
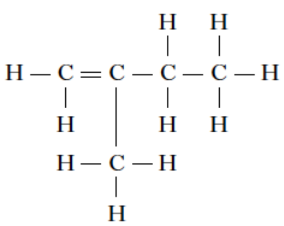


C



D



Q3. Which of the following compounds fits the general formula, C_nH_{2n}, and will rapidly decolourise bromine solution?

A cyclopentane

B pentane

C pentene

D cyclopentene

Q4. The properties of hydrocarbons depend on the sizes of their molecules. Compared with a hydrocarbon made up of small molecules, a hydrocarbon with large molecules will

A be more viscous

B be more flammable

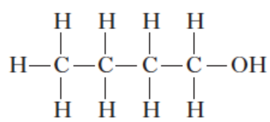
C evaporate more readily

D have a lower boiling point range

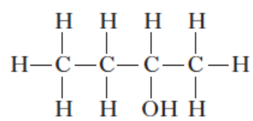
Q5. The structures for molecules of four liquids are shown below.

Which liquid will be the most viscous?

A



B



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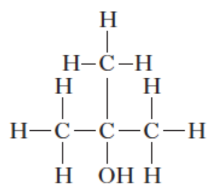

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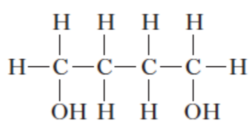
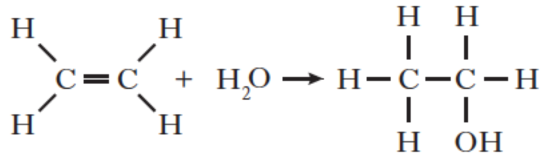


CHECK TEST 5.1

Q6.



The above equation represents

A hydration

B hydrogenation

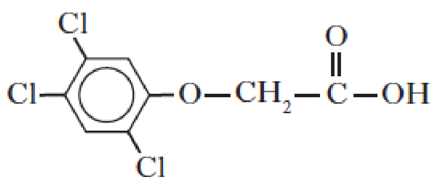
C condensation

D hydrolysis

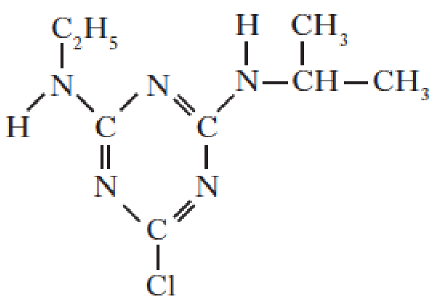
Q7. The following molecules are found in herbicides.

Which of the following contains an amide link?

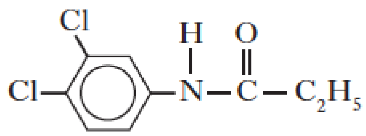
A



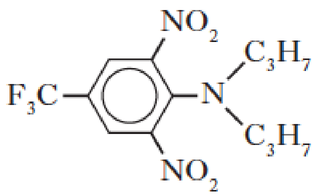
B



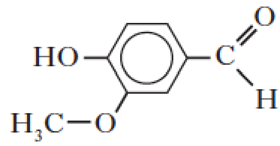
C



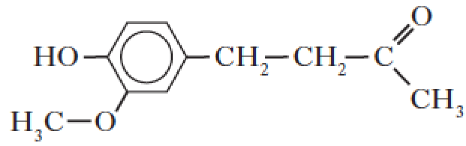
D



Q8. Vanillin and zingerone are flavour molecules.



vanillin



zingerone

Which line in the table correctly compares the properties of vanillin and zingerone?

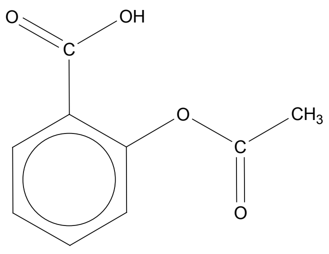
	More soluble in water	*More volatile*
A	vanillin	vanillin
B	vanillin	zingerone
C	zingerone	vanillin
D	zingerone	zingerone

Q9. Which line in the table shows the correct functional group for each homologous series?

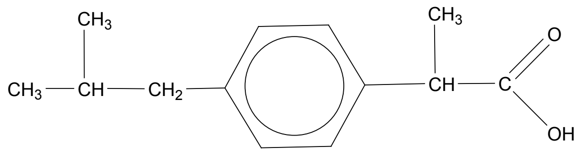
	Carboxylic acid	*Alcohol*	*Aldehyde*
A	–C(=O)H	–OH	–C(=O)OH
B	–C(=O)OH	–OH	–C(=O)H
C	–C(=O)OH	–C(=O)H	–OH
D	–OH	–C(=O)OH	–C(=O)H

Home Practice 5.1

Q1. The compounds shown below are active ingredients in over-the-counter drugs. Aspirin is used as an analgesic (to relieve pain) and as an antipyretic (to reduce elevated body temperatures). Ibuprofen is used as an anti-inflammatory agent (to counteract swelling or inflammation of the joints, skin and eyes).



Aspirin
(acetylsalicylic acid)



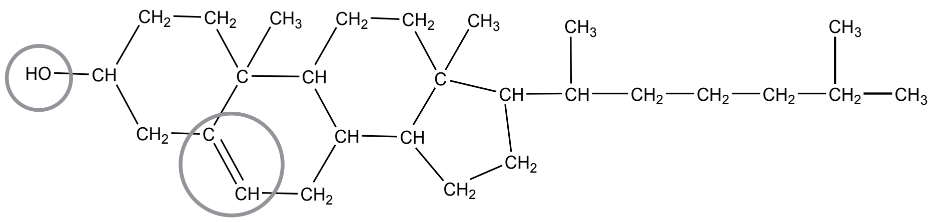
Ibuprofen

a) State which functional group is present in both drug molecules. **1**

b) State which functional group is present in aspirin but not in ibuprofen. **1**

c) Explain why aspirin is more water soluble than ibuprofen. **1**

Q2. Cholesterol is an important molecule present in the human body. However, high levels of a certain type of cholesterol in the blood are linked with illnesses such as heart disease and strokes.

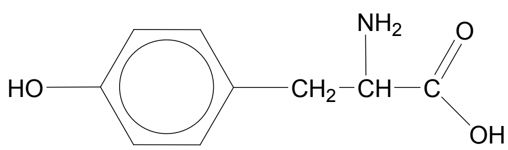


Cholesterol

a) Identify the two circled functional groups on the cholesterol molecule. **2**

b) Explain why this compound has a high boiling point. 2 reasons. **2**

Q3. L-tyrosine is an important building block in the formation of almost all proteins in the body.



L-tyrosine

Identify three functional groups present in its structure. **3**

HOME PRACTICE 5.1

Q4. The table shows the boiling points of some alcohols.

Alcohol	Boiling point/°C
$CH_3CH_2CH_2CH_2OH$	118
OH | $CH_3CH_2CHCH_3$	98
CH_3 | CH_3CHCH_2OH	108
$CH_3CH_2CH_2CH_2CH_2OH$	137
OH | $CH_3CH_2CH_2CHCH_3$	119
CH_3 | $CH_3CH_2CHCH_2OH$	128
OH | $CH_3CH_2CCH_3$ | CH_3	101
$CH_3CH_2CH_2CH_2CH_2CH_2OH$	159
CH_3 | $CH_3CH_2CH_2CHCH_2OH$	149
OH | $CH_3CH_2CH_2CCH_3$ | CH_3	121

Primary alcohols have their functional group at the end of the chain

—CH_2OH.

Secondary alcohols have their funcional group in the middle of a chain

|
—CHOH

Tertiary alcohols have their funcional group in the middle of a chain and a branch at the same place

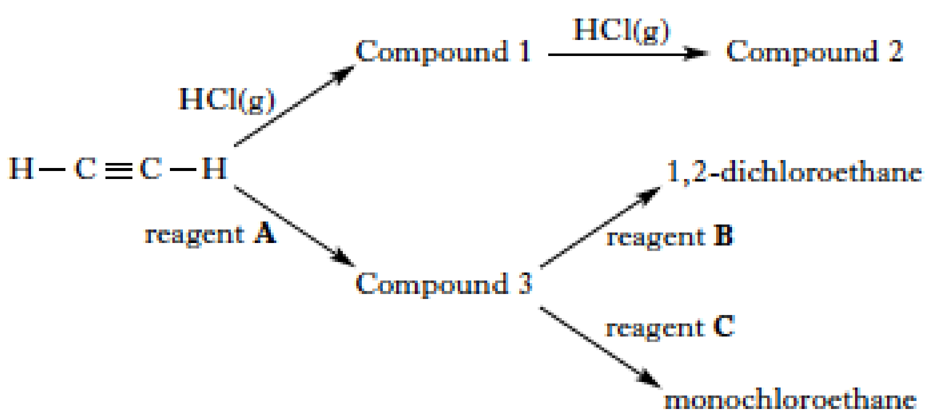
|
—COH
|

a) State which functional group is present in all of these molecules. **1**

b) Using information from the table, describe two ways in which differences in the structures affect boiling point of isomeric alcohols. **2**

c) Predict a boiling point for hexan-2-ol. **1**

Q5. Ethyne is the first member of the homologous series called the alkynes. Ethyne can undergo addition reactions as shown in the flow diagram.



a) Compound **2** is an isomer of 1,2-dichloroethane.
Draw a structural formula for compound **2**. **1**

b) Reagents **A**, **B** and **C** are three different diatomic gases.
Using information in the flow diagram, identify reagents **A**, **B** and **C**. **2**

Total (17)