IB · SL · Chemistry

2 hours 21 questions

Structured Questions

Functional Groups: Classification of Organic Compounds

Representing Formulas of Organic Compounds / Functional Groups / Homologous Series / IUPAC Nomenclature / Structural Isomers

Easy (5 questions)	/22
Medium (11 questions)	/65
Hard (5 questions)	/24
Total Marks	**/111**

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Easy Questions

1 (a) Define the term hydrocarbon.

.....

(1 mark)

(b) State the general formula for the following hydrocarbon families.

Alkanes .....

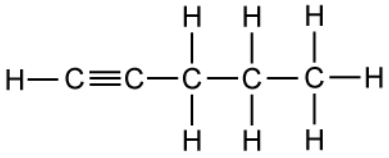
Alkenes .....

.....

.....

(2 marks)

(c) State the IUPAC name of the following hydrocarbon.



.....

(1 mark)

(d) A student stated that as the number of carbon atoms increases in an alkane, the boiling point increases. State if the student is correct and justify your answer.

(3 marks)

2 (a) Propanal and propanone have the same molecular formula, C_3H_6O, but have different structures. Draw the displayed structures of propanal and propanone.

.....

.....

(2 marks)

(b) State the type of isomerism that is exhibited by propanal and propanone.

.....

(1 mark)

(c) Butanone can be reduced to a secondary alcohol by $LiAlH_4$. State the name of this alcohol.

.....

(1 mark)

(d) State the general formula of an alcohol.

.....

(1 mark)

3 (a) Name the three possible isomers of C_5H_{12}.

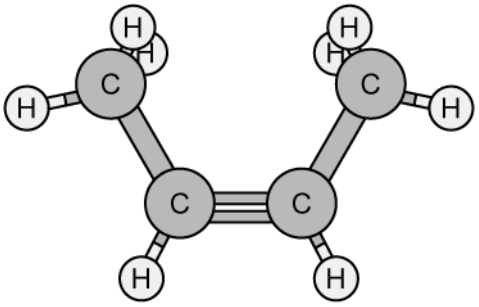
.....

.....

.....

(3 marks)

(b) Using IUPAC rules state the name of the molecule shown in the image below.



.....

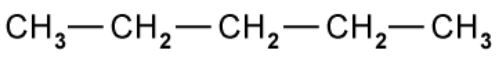
(1 mark)

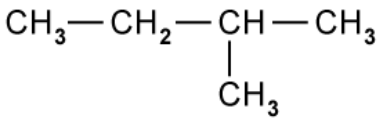
(c) Draw the sterochemical drawing of methane.

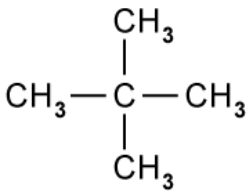
.....

(1 mark)

4 Three isomers of pentane are shown below.

A 

B 

C 

Give the IUPAC names of isomers **B** and **C.**

.....

.....

(2 marks)

5 (a) Define the term *stereoisomers*.

.....

(1 mark)

(b) State the conditions needed for a compound to show cis-trans isomerism.

.....

.....

(2 marks)

Medium Questions

1 (a) Organic compounds are classified into families called a *homologous series*.

State three features of members belonging to the same *homologous series*.

.....

.....

.....

(3 marks)

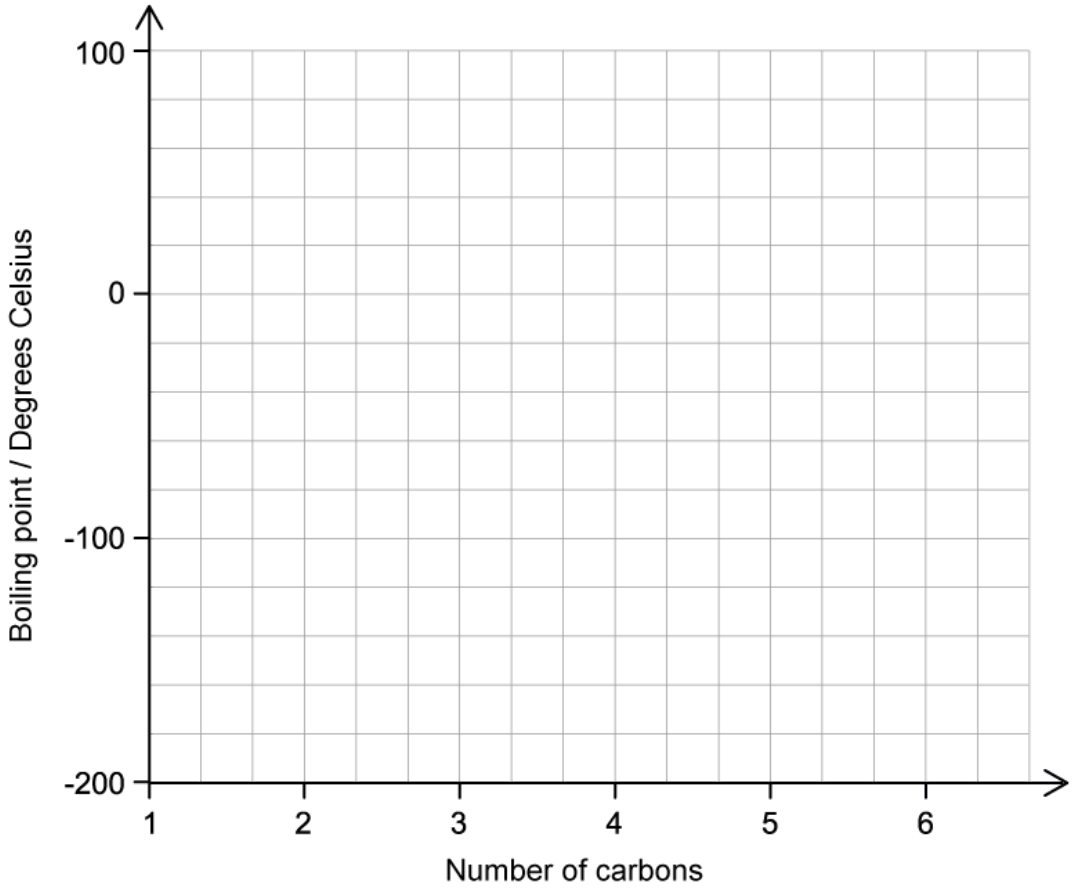
(b) **Table 1** shows the boiling points of the first five members of the alkane family.

Table 1

Alkane	Boiling point/ ^{o}C
methane	-162
ethane	-89
propane	-42
butane	-1
pentane	36

On the axes below in **Figure 1,** draw a graph of boiling point against the number of carbon atoms in the alkanes. Estimate the boiling point of the next member of the homologous series, hexane, C_6H_{14}, and show on your graph how you arrived at your estimated boiling point.

Figure 1



Estimated boiling point of hexane : _____ ^{o}C

(4 marks)

(c) State the general formula for an alkyne and give the molecular formula and name of the fifth member of the alkyne family.

(2 marks)

(d) The boiling point of ethyne, C_2H_2, is -84 ^oC.

State with, with a reason, whether the boiling point of ethyne would be expected to be higher or lower than the boiling point of ethane, C_2H_6.

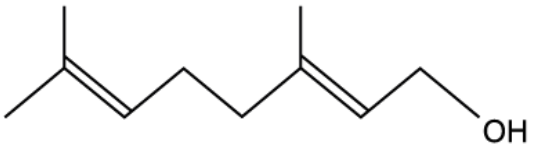
.....

.....

(2 marks)

2 (a) Geraniol is a colourless component of rose oil whose structure is shown in **Figure 1**.

Figure 1



i) State the names of the two functional groups found in geraniol.

[1]

ii) Deduce the molecular formula of geraniol.

[1]

iii) Draw the displayed formula of geraniol.

[1]

.....

.....

.....

(3 marks)

(b) Butan-2-ol is an organic compound used industrially to make butanone.

i) Draw the displayed structure of butan-2-ol.

[1]

ii) Draw the displayed structures of a positional isomer and a functional group isomer of butan-2-ol.

[2]

.....

.....

.....

(3 marks)

(c) Draw and name all the branched-chain isomers of butan-2-ol.

.....

.....

(2 marks)

(d) State, with a reason, the class of alcohols which butan-2-ol belongs to.

.....

(1 mark)

3 (a) The formulae of four organic compounds are given in **Table 1**. Write the names of the compounds in the second column.

Table 1

compound	name
$CH_3CH_2CH_2CH(OH)CH_3$	
$CH_3CH_2COCH_3$	
$CH_3CH_2CH_2OH$	
$CH_3CH_2CH_2CHO$	

.....

.....

(2 marks)

(b) Which of the compounds in part (a) are structural isomers of each other and what type of isomerism do they show?

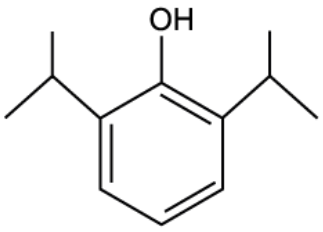
.....

.....

(2 marks)

(c) Propofol is a drug used to reduce consciousness during medical procedures. The skeletal structure of propofol is given in Figure 1.

Figure 1



i) Determine the empirical formula of propofol.

[1]

ii) Identify the number of positional isomers of propofol (not including propofol).

[1]

iii) State the names of two functional groups found in propofol.

[1]

.....

.....

.....

(3 marks)

(d) Valeric acid, $C_5H_{10}O_2$, is a straight chain carboxylic acid found in the plant *Valeriana officinalis*.

i) State the general formula for a carboxylic acid.

[1]

ii) Give the systematic name for valeric acid.

[1]

iii) Draw a condensed structural formula for valeric acid.

[1]

.....

.....

.....

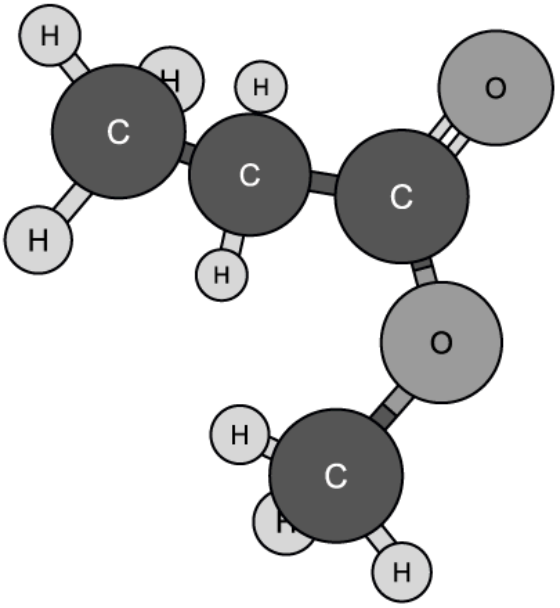
(3 marks)

4 (a) Draw and name all the possible isomers of C_6H_{14}.

(5 marks)

(b) **Figure 1** below shows a three-dimensional structure of a molecule.

Figure 1



i) Using IUPAC rules state the name of this molecule.

[1]

ii) Draw and name a functional group isomer of this molecule.

[1]

(2 marks)

5 (a) Toluene is a common organic chemical with many industrial and commercial applications. Toluene is also known as methylbenzene.

Draw the molecular structure of toluene.

(1 mark)

(b) Another derivative of benzene has the molecular formula C_8H_{10}.

Draw the structures of the four possible isomers of this derivative.

(2 marks)

6 (a) The analytical instruments used for identification of organic compounds are constantly being improved.

Mass spectroscopy is one such analytical tool which provides key information used to identify an unknown compound.

An unknown compound has the empirical formula C_2H_4O, and its mass spectrum has a molecular ion peak at *m/z* 84.

Deduce the molecular formula of the compound.

(1 mark)

(b) The unknown compound is a carboxylic acid. Deduce the two possible carboxylic acid structural isomers.

(2 marks)

7 A group of students are asked to distinguish between four samples of different organic compounds.

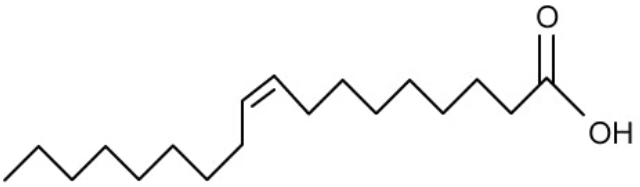
The four samples are as follows:

- A primary alcohol
- A tertiary alcohol
- An aldehyde
- A carboxylic acid

Describe how the group of students could distinguish between the two different alcohols.

(3 marks)

8 (a) A molecule of oleic acid is shown.



Oleic acid

Oleic acid is a fatty acid which occurs naturally in different animals and plants.

Oleic acid exhibits *stereoisomerism*. Explain the meaning of this term and identify why oleic acid has stereoisomers.

.....

.....

(2 marks)

(b) Crotonic acid is another fatty acid which has a similar structure to oleic acid. The molecular formula of crotonic acid is $C_4H_6O_2$.

i) State the empirical formula of crotonic acid.

[1]

ii) Crotonic acid has a carboxylic acid functional group. Draw the displayed formula of the positional and branch-chain isomers of crotonic acid.

[2]

iii) Identify which of the isomers you have drawn shows *E / Z* isomerism.

[1]

.....

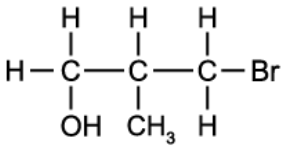
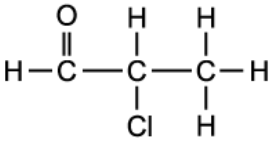
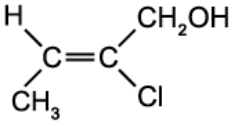
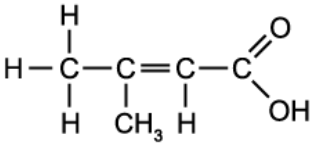
.....

.....

.....

(4 marks)

9 (a) A chemist is analysing a collection of organic compounds. The structural formulae of these compounds are shown.

Compound	Structural Formula	IUPAC Name
1		
2		
3		
4		

Give the IUPAC name for the compounds to complete the table.

(4 marks)

(b) This question refers to the compounds in the table in part (a)

i) Identify the compounds which have chain isomers and draw their isomers.

[3]

ii) State the empirical formula of compound **3.**

[1]

iii) Does compound 4 exhibit stereoisomerism? Explain your answer.

[1]

(5 marks)

10 2-methylbut-2-ene can be converted into 2-methylbutan-2-ol, a liquid that smells of camphor.

State the reagents needed to convert 2-methylbut-2-ene into 2-methylbutan-2-ol.

(2 marks)

11 (a) Dichloroethene exists as two stereoisomers. Draw the structures of these isomers.

.....

(1 mark)

(b) Explain why dichloroethene has stereoisomers.

.....

(1 mark)

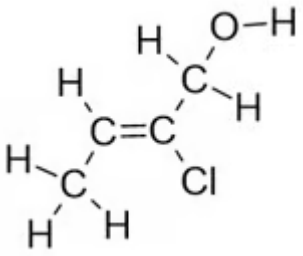
Hard Questions

1 (a) State the IUPAC names for the isomers of $C_5H_{12}O$ that are primary alcohols.

(4 marks)

(b) State the IUPAC name for the following primary alcohols.

i)



[1]

ii) $CH_2(Br)CH(CH_3)CH_2OH$

[1]

(2 marks)

(c) Draw the displayed formula for a straight chain isomer of $CH_2(Br)CH(CH_3)CH_2OH$.

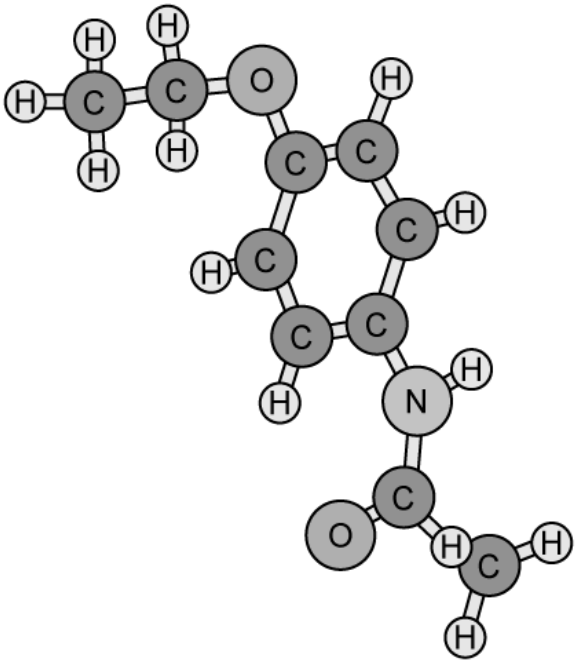
(1 mark)

(d) The empirical formula of the compound in part b) i).

.....

(1 mark)

2 (a) Phenacetin is a pain killer though the use of this was banned as it was found to cause harm to kidney function.



Deduce the molecular formula of phenacetin.

.....

(1 mark)

(b) Identify the names of the three functional groups present in phenacetin.

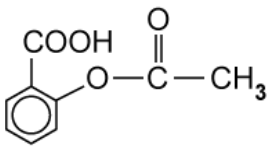
.....

.....

.....

(3 marks)

(c) Aspirin is a common pain killer and has the following structure.

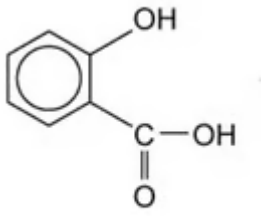


State the empirical formula of aspirin.

.....

(1 mark)

(d) Aspirin is formed from ethanoic anhydride and compound A. State the IUPAC name of compound **A**.



Compound A

.....

(1 mark)

Deduce the number of isomers of C_6H_{14}.

3 (a) **(1 mark)**

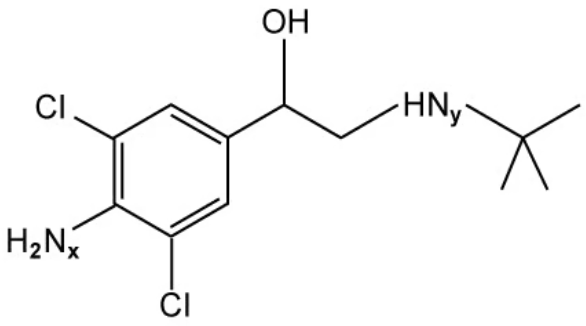
State the IUPAC name of **two** branched isomers of C_6H_{14}.

(b) **(2 marks)**

Draw the displayed formula of a possible isomer of C_6H_{12} that does **not** contain a π bond.

(c) **(1 mark)**

4 Clenbuterol, shown below, is considered a performance enhancing drug and is believed to increase short term work rate and cardiovascular output.



Deduce the functional groups marked *x* and *y* and state to which class they belong to.

(2 marks)

5 Lactic acid has the molecular formula of $C_3H_6O_3$, and the structural formula of $CH_3CHOHCOOH$.

Illustrate the types of isomerism shown by $C_3H_6O_3$.

(4 marks)