



Introduction to Organic Chemistry Test



Answer ALL Questions. Max 80 marks. To Pass the Introduction to Organic Chemistry Test you will need to achieve a score of greater than 70%.

1. The alkanes form an homologous series of hydrocarbons. The first four straight-chain alkanes are shown below.

methane	CH_4
ethane	CH_3CH_3
propane	$\text{CH}_3\text{CH}_2\text{CH}_3$
butane	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$

- (a) (i) State what is meant by the term *hydrocarbon*.

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- (ii) Give the general formula for the alkanes.

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- (iii) Give the molecular formula for hexane, the sixth member of the series.

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(3)

- (b) Each homologous series has its own general formula. State **two** other characteristics of an homologous series.

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(2)

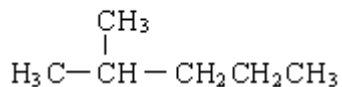
(c) Branched-chain structural isomers are possible for alkanes which have more than three carbon atoms.

(i) State what is meant by the term *structural isomers*.

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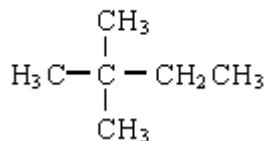
(ii) Name the **two** isomers of hexane shown below.

Isomer 1



Name

Isomer 2



Name

(iii) Give the structures of **two** other branched-chain isomers of hexane.

Isomer 3

Isomer 4

(6)

(d) A hydrocarbon, **W**, contains 92.3% carbon by mass. The relative molecular mass of **W** is 78.0

(i) Calculate the empirical formula of **W**.

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(ii) Calculate the molecular formula of **W**.

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(4)

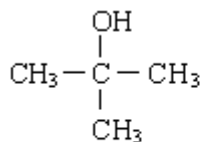
(Total 15 marks)

2. (a) An alcohol containing carbon, hydrogen and oxygen only has 64.9% carbon and 13.5% hydrogen by mass. Using these data, show that the empirical formula of the alcohol is $C_4H_{10}O$

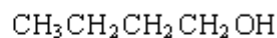
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(3)

(b) The structural formulae of two of the four possible alcohols of molecular formula $C_4H_{10}O$ are shown below.



Isomer 1



Isomer 2

Draw the structural formulae of the two remaining alcohols of molecular formula $C_4H_{10}O$

Isomer 3

Isomer 4

(2)

(Total 5 marks)

3. (a) Compounds with double bonds between carbon atoms can exhibit geometrical isomerism.

(i) Draw structures for the two geometrical isomers of 1,2-dichloroethene.

Isomer 1

Isomer 2

(ii) What feature of the double bond prevents isomer 1 from changing into isomer 2?

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(3)

(Total 3 marks)

4. The fractions obtained from petroleum contain saturated hydrocarbons that belong to the homologous series of alkanes.

(a) Any homologous series can be represented by a general formula.

(i) State **two** other characteristics of homologous series.

Characteristic 1

.....

Characteristic 2

.....

(ii) Name the process which is used to obtain the fractions from petroleum.

.....

(iii) State what is meant by the term *saturated*, as applied to hydrocarbons.

.....

.....

(4)

(b) Decane has the molecular formula $C_{10}H_{22}$

(i) State what is meant by the term *molecular formula*.

.....

.....

(ii) Give the molecular formula of the alkane which contains 14 carbon atoms.

.....

(iii) Write an equation for the incomplete combustion of decane, $C_{10}H_{22}$, to produce carbon and water only.

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(3)

(c) When petrol is burned in an internal combustion engine, some nitrogen monoxide, NO, is formed. This pollutant is removed from the exhaust gases by means of a reaction in a catalytic converter.

(i) Write an equation for the reaction between nitrogen and oxygen to form nitrogen monoxide.

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(ii) Identify a catalyst used in a catalytic converter.

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(iii) Write an equation to show how nitrogen monoxide is removed from the exhaust gases as they pass through a catalytic converter.

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(3)

(Total 10 marks)

5. The table below gives some of the names and structures of isomers having the molecular formula C_4H_9Br

Structure	Name
$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}$	
$\begin{array}{c} \text{CH}_3 \\ \\ \text{H}_3\text{C} - \text{C} - \text{CH}_3 \\ \\ \text{Br} \end{array}$	2-bromo - 2-methypropane
	1-bromo - 2-methypropane
$\begin{array}{c} \text{CH}_3\text{CH}_2 - \text{CH} - \text{CH}_3 \\ \\ \text{Br} \end{array}$	2-methypropane

Complete the table.

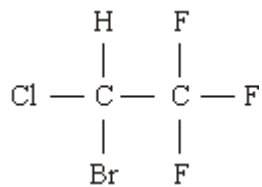
(Total 2 marks)

6. (a) The compound 1,2-dibromo-1,1,2,2-tetrafluoroethane is used in some fire extinguishers.

Draw the structure of this compound.

(1)

- (b) Halothane is used as an anaesthetic and has the following structure.



- (i) Give the systematic name of *halothane*.

.....

- (ii) Calculate the M_r of halothane.

.....

- (iii) Calculate the percentage by mass of fluorine in halothane.

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(3)
(Total 4 marks)

7. Petrol contains saturated hydrocarbons. Some of the molecules in petrol have the molecular formula C_8H_{18} and are referred to as octanes. These octanes can be obtained from crude oil by fractional distillation and by cracking suitable heavier fractions.

Petrol burns completely in a plentiful supply of air but can undergo incomplete combustion in a car engine.

- (a) State the meaning of both the words *saturated* and *hydrocarbon* as applied to the term *saturated hydrocarbon*.

Name the homologous series to which C_8H_{18} belongs.

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(3)

- (b) Outline the essential features of the fractional distillation of crude oil that enable the crude oil to be separated into fractions.

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(4)

- (c) C_8H_{18} is obtained by the catalytic cracking of suitable heavy fractions. State what is meant by the term *cracking* and name the catalyst used in catalytic cracking.

Write an equation to show how one molecule of $C_{14}H_{30}$ is cracked to form one molecule of C_8H_{18} and one molecule of another hydrocarbon.

Explain why oil companies need to crack 'suitable heavy fractions'.

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(4)

- (d) Write an equation for the incomplete combustion of C_8H_{18} to form carbon monoxide and water only.

A catalytic converter is used to remove carbon monoxide from the exhaust gases in a car. Identify a catalyst used in the catalytic converter.

Write an equation to show how carbon monoxide is removed in a catalytic converter.

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(3)

- (e) When some petrol was accidentally contaminated in 2007, the sensors in the affected cars caused a decrease in the supply of petrol to the engine.

Suggest the effect that the contaminated fuel would have on the performance of the cars.

State how the oil company might have recognised the problem before the petrol was sold.

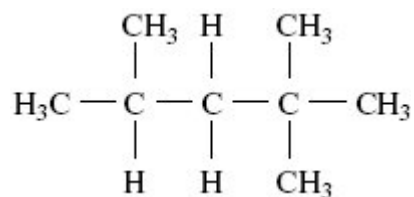
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(2)

- (f) The molecular formula C_8H_{18} represents several structural isomers.

State what is meant by the term *structural isomers*.

Name the following structural isomer of C_8H_{18}



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(3)

(Total 19 marks)

8. Hexane is a member of the homologous series of alkanes.

(a) State **two** characteristics of a *homologous series*.

Characteristic 1

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Characteristic 2

.....

(2)

(b) (i) Hexane can be converted into 2,2-dichlorohexane.

Draw the displayed formula of 2,2-dichlorohexane and deduce its empirical formula.

Displayed formula

Empirical formula

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(2)

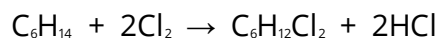
(ii) Explain why 2,2-dichloro-3-methylpentane is a structural isomer of 2,2-dichlorohexane.

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(2)

(c) A reaction of hexane with chlorine is shown by the equation below.



Calculate the percentage atom economy for the formation of $C_6H_{12}Cl_2$ in this reaction.

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(2)

(d) The boiling points of some straight-chain alkanes are shown below.

Alkane	C_4H_{10}	C_5H_{12}	C_6H_{14}
Boiling point / °C	- 0.5	36.3	68.7

(i) Explain the trend in these boiling points.

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(2)

(ii) Name a process which can be used to separate C_5H_{12} from C_6H_{14}

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(1)

(Total 11 marks)

9. Alkenes are useful intermediates in the synthesis of organic compounds.

(i) Draw structures for the E and Z stereoisomers of hex-3-ene.

E isomer of hex-3-ene

Z isomer of hex-3-ene

(2)

(ii) State the meaning of the term *stereoisomers*.

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(2)

(Total 4 marks)

10. The reaction of bromine with an alkene is used in a test to show that the alkene is unsaturated.

(a) State what is meant by the term *unsaturated* as applied to an alkene.

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(1)

(b) But-2-ene can exist as a pair of stereoisomers.

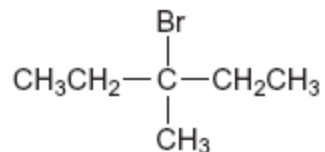
Draw the structure of (*E*)-but-2-ene.

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(1)

(Total 2 marks)

11. The compound P has the structure shown below:



(i) Name the major product **P**.

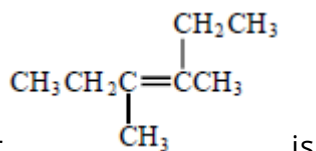
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(1)

(ii) Draw the structure of the (E)-stereoisomer of 3-methylpent-2-ene.

(1)

(Total 2 marks)



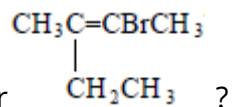
12. The correct systematic name for

is

- A 2,3-diethylbut-2-ene
- B 2-ethyl-3-methylpent-2-ene
- C 4-ethyl-3-methylpent-3-ene
- D 3,4-dimethylhex-3-ene

(Total 1 mark)

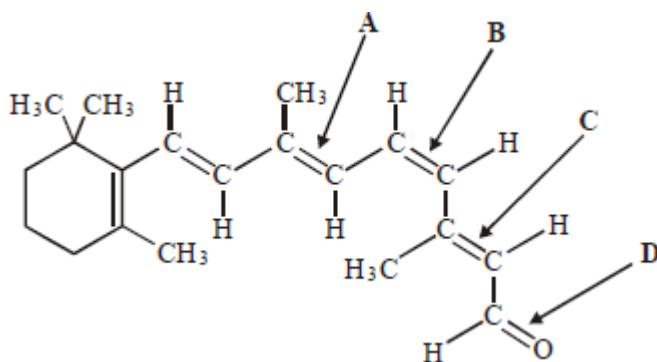
13. Which one of the following is the correct name for



- A 2-bromo-3-methylpent-2-ene
- B 2-bromo-3-ethylbut-2-ene
- C 3-bromo-2-ethylbut-2-ene
- D 4-bromo-3-methylpent-3-ene

(Total 1 mark)

14. The compound *cis*-retinal is shown below.



Which one of the labelled bonds leads to the prefix in the name?

(Total 1 mark)