AQA A-LEVEL CHEMISTRY · 7405

CHEMISTRY



EXAM QUESTION PACK

3.3.1 INTRODUCTION TO ORGANIC CHEMISTRY

SCORE	PERCENTAGE
/280	%

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Q1.

A hydrocarbon contains 87.8% by mass of carbon and has a relative molecular mass (M_r) of 82.0
The hydrocarbon decolourises bromine water.

Determine the empirical and molecular formulae of the hydrocarbon.
Suggest **two** possible structures for the hydrocarbon.
Name the type of reaction taking place when bromine water reacts with the hydrocarbon.

_____

_____

_____

_____

_____

_____

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_____

_____

_____

_____

(Total 6 marks)

Q2.

How many structural isomers with an unbranched carbon chain have the molecular formula $C_4H_8Br_2$?

A 4 ⬭

B 5 ⬭

C 6 ⬭

D 7 ⬭

(Total 1 mark)

Q3.

The oxidation of propan-1-ol can form propanal and propanoic acid.
The boiling points of these compounds are shown in the table.

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Compound	Boiling point / °C
propan-1-ol	97
propanal	49
propanoic acid	141

In a preparation of propanal, propan-1-ol is added dropwise to the oxidising agent and the aldehyde is separated from the reaction mixture by distillation.

(a) Explain, with reference to intermolecular forces, why distillation allows propanal to be separated from the other organic compounds in this reaction mixture.

(3)

(b) Give **two** ways of maximising the yield of propanal obtained by distillation of the reaction mixture.

1.

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2. _____

_____

_____

_____

_____

_____

(2)

(c) Describe how you would carry out a simple test-tube reaction to confirm that the sample of propanal obtained by distillation does **not** contain any propanoic acid.

_____

_____

_____

_____

_____

_____

(2)

(d) A student carried out an experiment to determine the enthalpy of combustion of ethanol.
Combustion of 457 mg of ethanol increased the temperature of 150 g of water from 25.1 °C to 40.2 °C

Calculate a value, in kJ mol^{-1}, for the enthalpy of combustion of ethanol in this experiment.
Give your answer to the appropriate number of significant figures.

(The specific heat capacity of water is 4.18 J K^{-1} g^{-1})

Enthalpy of combustion _____ kJ mol^{-1}

(3)

(e) A mixture of isomeric alkenes is produced when pentan-2-ol is dehydrated in the presence of hot concentrated sulfuric acid. Pent-1-ene is one of the isomers produced.

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Name and outline a mechanism for the reaction producing pent-1-ene.

Name of mechanism _____

Mechanism

(4)

(f) A pair of stereoisomers is also formed in the reaction in **part (e)**.

Name the less polar stereoisomer formed.
Explain how this type of stereoisomerism arises.

Name _____

Explanation _____

_____

_____

_____

(2)

(Total 16 marks)

Q4.

How many structural isomers with the molecular formula $C_5H_{10}O$ react with Tollens' reagent?

A 3 ⬭

B 4 ⬭

C 5 ⬭

D 6 ⬭

(Total 1 mark)

Q5.

This question is about the structures of some organic molecules.

(a) Draw the **skeletal** formula of 3-methylbutanal.

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(1)

(b) Draw the **displayed** formula of $C_5H_{11}Br$ that is the major product of the reaction of 2-methylbut-2-ene with hydrogen bromide.

(1)

(c) Thermal cracking of hydrocarbons produces molecules that are attacked by electrophiles because they have a region of high electron density.

Draw the structure of one of these molecules that contains four carbon atoms.

(1)

(Total 3 marks)

Q6.

How many structural isomers are there with the molecular formula C_3H_6BrCl?

A 4 ⬭

B 5 ⬭

C 6 ⬭

D 7 ⬭

(Total 1 mark)

Q7.

Which compound does **not** show stereoisomerism?

A 1,2-dichloropropene ⬭

B 1,2-dichloropropane ⬭

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C 1,3-dichloropropene ⬭

D 1,3-dichloropropane ⬭

(Total 1 mark)

Q8.

Avgas is an aviation fuel used in the internal combustion engines of helicopters.
It consists of a large number of hydrocarbons, including a high proportion of hexane, which can exist as several isomers.

(a) Draw the skeletal formulae of **two** branched isomers of hexane.

(1)

(b) State the type of isomerism shown by these branched isomers.

_____

(1)

(c) Safety signs on the fuselage of the helicopter state that the air inlets to the engine need to be cleaned out regularly.

Write an equation for the combustion of hexane that would happen in the helicopter engine if the air inlets were partially blocked with debris.

_____

(2)

(d) Suggest how this partial blockage might affect the performance of the helicopter engine.

_____

_____

_____

(1)

(Total 5 marks)

Q9.

What is the total number of structural isomers with the molecular formula $C_2HBrClF_3$?

A 2 ⬭

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B 3 ⬭

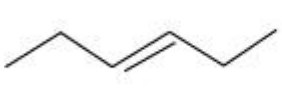
C 4 ⬭

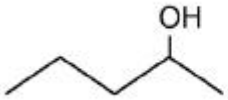
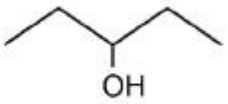
D 5 ⬭

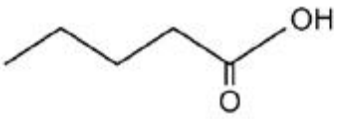
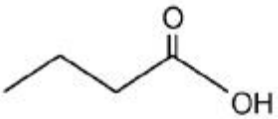
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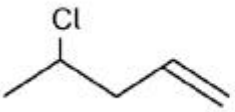
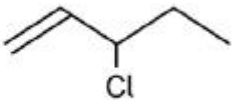
Q10.

Which is a pair of functional group isomers?

A   ⬭

B   ⬭

C   ⬭

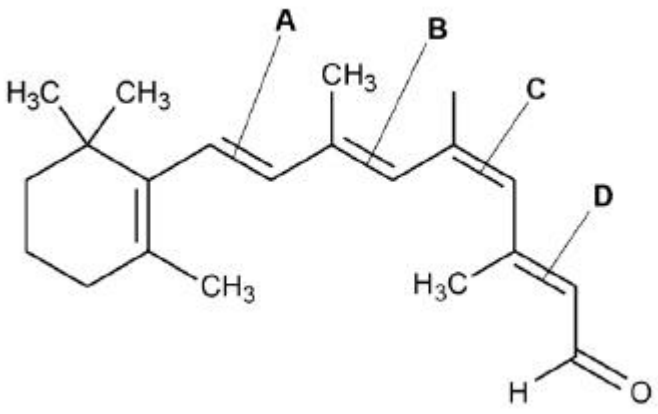
D   ⬭

(Total 1 mark)

Q11.

Z-Retinal, shown in the diagram, is a component in vitamin A.

Which of the double bonds, labelled **A**, **B**, **C** or **D**, is responsible for the letter Z in the name?



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A ⬭

B ⬭

C ⬭

D ⬭

(Total 1 mark)

Q12.

This question is about isomerism.

(a) How many isomers are represented by the formula C_5H_{12}?

Tick (✓) **one** box.

2 ☐ 3 ☐ 4 ☐ 5 ☐

(b) Name the type of structural isomerism shown by the isomers of C_5H_{12}

_____

(1)

(c) 2-Hydroxypropanenitrile displays optical isomerism.

Draw three-dimensional representations of the two enantiomers of 2-hydroxypropanenitrile, showing how the two structures are related to each other.

(2)

(d) Describe how separate samples of each of these enantiomers could be distinguished.

_____

_____

_____

_____

(2)

(e) Butan-2-ol reacts with concentrated sulfuric acid to produce three isomeric alkenes.

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Name and outline a mechanism to show how any **one** of the alkenes is formed.

Explain how this reaction can lead to the formation of each of these **three** alkenes.

Name of mechanism _____

Mechanism

Explanation _____

_____

_____

_____

_____

_____

_____

_____

_____

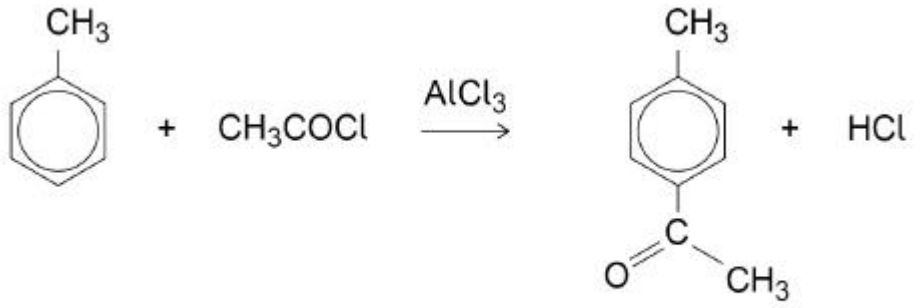
(8)

(Total 13 marks)

Q13.

When methylbenzene reacts with ethanoyl chloride in the presence of aluminium chloride, the product, **H**, is formed.

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H

(a) Deduce the molecular formula of **H**.

_____

(1)

(b) Two other isomers are also produced in the reaction.

Draw the structure of **one** of the other isomers.

Name the type of structural isomerism shown by these three products.

Structure

Type of isomerism _____

(2)

(c) Name and outline the mechanism for the reaction of ethanoyl chloride with methylbenzene to produce **H**.

Include an equation for the formation of the reactive intermediate that is involved in the reaction.

Name _____

Equation _____

Mechanism

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(5)

(Total 8 marks)

Q14.

Compound **J**, known as leaf alcohol, has the structural formula $CH_3CH_2CH{=}CHCH_2CH_2OH$ and is produced in small quantities by many green plants. The *E* isomer of **J** is responsible for the smell of freshly cut grass.

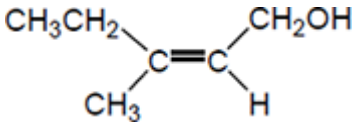
(a) Give the structure of the *E* isomer of **J**.

(1)

(b) Give the **skeletal formula** of the organic product formed when **J** is dehydrated using concentrated sulfuric acid.

(1)

(c) Another structural isomer of **J** is shown below.



Explain how the Cahn-Ingold-Prelog (CIP) priority rules can be used to deduce the full IUPAC name of this compound.

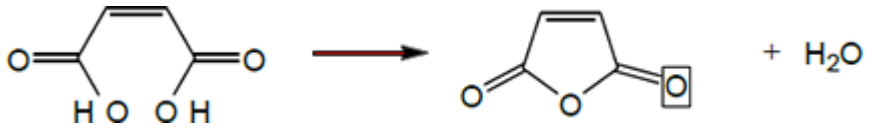
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_____

_____

(6)

(d) The effect of gentle heat on maleic acid is shown below.



A student predicted that the yield of this reaction would be greater than 80%.

In an experiment,10.0 g of maleic acid were heated and 6.53 g of organic product were obtained.

Is the student correct? Justify your answer with a calculation using these data.

_____

_____

_____

(2)

(Total 10 marks)

Q15.

2-bromo-2-methylpentane is heated with potassium hydroxide dissolved in ethanol. Two structural isomers are formed.

(a) State the meaning of the term **structural isomers**.

_____

_____

_____

(1)

(b) Name and draw the mechanism for the formation of **one** of the isomers.

Name of mechanism _____

Mechanism

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(5)
(Total 6 marks)

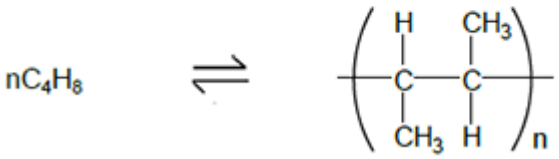
Q16.

Dodecane ($C_{12}H_{26}$) is a hydrocarbon found in the naphtha fraction of crude oil. Dodecane can be used as a starting material to produce a wide variety of useful products. The scheme below shows how one such product, polymer **Y**, can be produced from dodecane.

Reaction 1

$C_{12}H_{26} \longrightarrow C_2H_4 + C_4H_8 + \mathbf{X}$

Reaction 2



Polymer **Y**

(a) Name the homologous series that both C_2H_4 and C_4H_8 belong to.
Draw a functional group isomer of C_4H_8 that does **not** belong to this homologous series.

Name _____

Functional group isomer

(2)

(b) Identify compound **X**.

_____

(1)

(c) Name polymer **Y**.

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_____

(1)

(d) Reaction **1** is an example of thermal cracking and is carried out at a temperature of 750 °C.

State **one other** reaction condition needed.

_____

(1)

(e) Reaction **2** is exothermic. A typical compromise temperature of 200 °C is used industrially for this reaction.

Explain the effect of a change of temperature on both the position of equilibrium and the rate of reaction, and justify why a compromise temperature is used industrially.

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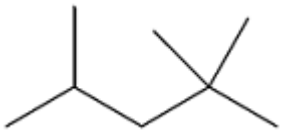
_____

(6)

(Total 11 marks)

Q17.

Isooctane (C_8H_{18}) is the common name for the branched-chain hydrocarbon that burns smoothly in car engines. The skeletal formula of isooctane is shown below.



(a) Give the IUPAC name for isooctane.

_____

(1)

(b) Deduce the number of peaks in the ^{13}C NMR spectrum of isooctane.

5 ⬭

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6 ⬭

7 ⬭

8 ⬭

(1)

(c) Isooctane can be formed, together with propene and ethene, in a reaction in which one molecule of an alkane that contains 20 carbon atoms is cracked.

Using molecular formulas, write an equation for this reaction.

_____

(1)

(d) How do the products of the reaction in part (c) show that the reaction is an example of thermal cracking?

_____

(1)

(e) Deduce the number of monochloro isomers formed by isooctane.
Draw the structure of the monochloro isomer that exists as a pair of optical isomers.

Number of monochloro isomers

_____

Structure

(2)

(f) An isomer of isooctane reacts with chlorine to form only one monochloro compound.

Draw the **skeletal formula** of this monochloro compound.

(1)

(g) A sample of a monochlorooctane is obtained from a comet. The chlorine in the

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monochlorooctane contains the isotopes ^{35}Cl and ^{37}Cl in the ratio 1.5 : 1.0
Calculate the M_r of this monochlorooctane.

M_r = _____

(2)

(h) Isooctane reacts with an excess of chlorine to form a mixture of chlorinated compounds.
One of these compounds contains 24.6% carbon and 2.56% hydrogen by mass.
Calculate the molecular formula of this compound.

Molecular formula = _____

(3)

(Total 12 marks)

Q18.

How many isomers have the molecular formula C_5H_{12}?

A 2 ⬭

B 3 ⬭

C 4 ⬭

D 5 ⬭

(Total 1 mark)

Q19.

How many structural isomers have the molecular formula C_4H_9Br?

A 2 ⬭

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B 3 ⬭

C 4 ⬭

D 5 ⬭

(Total 1 mark)

Q20.

How many secondary amines have the molecular formula $C_4H_{11}N$?

A 2 ⬭

B 3 ⬭

C 4 ⬭

D 5 ⬭

(Total 1 mark)

Q21.

The alkene 3-methylpent-2-ene ($CH_3CH=C(CH_3)CH_2CH_3$) reacts with hydrogen bromide to form a mixture of 3-bromo-3-methylpentane and 2-bromo-3-methylpentane.

(a) The alkene 3-methylpent-2-ene ($CH_3CH=C(CH_3)CH_2CH_3$) exists as *E* and *Z* stereoisomers.

Draw the structure of *Z*-3-methylpent-2-ene.

(1)

(b) Name and outline the mechanism for the formation of 3-bromo-3-methylpentane from this reaction of 3-methylpent-2-ene with hydrogen bromide.

Explain why more 3-bromo-3-methylpentane is formed in this reaction than 2-bromo-3-methylpentane.

_____

_____

_____

_____

_____

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_____

_____

_____

_____

_____

_____

_____

(7)

(Total 8 marks)

Q22.

The structure of cyclohexene is shown.



Which of the following is the general formula of cyclic alkenes such as cyclohexene?

A C_nH_{2n-4} ⬭

B C_nH_{2n-2} ⬭

C C_nH_{2n} ⬭

D C_nH_{2n+2} ⬭

(Total 1 mark)

Q23.

(a) Octane (C_8H_{18}) is an important compound in petrol.

(i) Identify the homologous series to which octane belongs.

_____

(1)

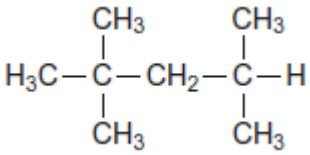
(ii) Write an equation to show the complete combustion of C_8H_{18}

_____

(1)

(iii) An isomer of octane used to improve the performance of car engines is shown.

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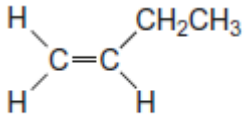


Give the IUPAC name of this isomer.

_____

(1)

(b) Compound **X** is produced when an alkane is cracked.



X

(i) Give the IUPAC name for compound **X**.

_____

(1)

(ii) One molecule of an alkane is cracked to produce one molecule of compound **X**, one molecule of octane and one molecule of ethene.

Deduce the molecular formula of this alkane.

_____

(1)

(iii) Name the type of cracking that produces a high yield of compound **X**. Give **two** conditions required for this process.

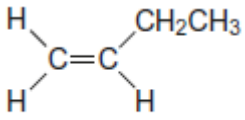
Type of cracking _____

Conditions _____

_____

(2)

(iv) Compound **X** has several isomers. The structure of **X** is repeated here.



X

Draw the displayed formula of a chain isomer, a position isomer and a functional group isomer of compound **X**.

Type of isomer	**Displayed formula of isomer of compound X**

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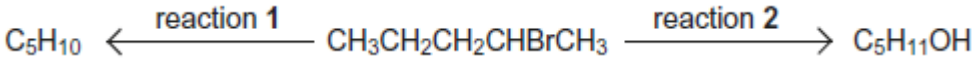
Chain	
Position	
Functional group	

(3)

(Total 10 marks)

Q24.

Two reactions of 2-bromopentane, ($CH_3CH_2CH_2CHBrCH_3$) are shown.



The C_5H_{10} formed in reaction **1** exists as a mixture of three isomers, one of which is pent-1-ene. Two of the isomers are a pair of stereoisomers. All three isomers decolourise bromine.

(a) The same reagent is used in both reactions. The product is determined by the choice of conditions.

State the reagent and the conditions for each of reaction **1** and reaction **2**.

State the role of the reagent in each reaction.

Name and outline the mechanism of reaction **1** for the formation of pent-1-ene.

_____

_____

_____

_____

_____

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(8)

(b) All three isomers of C_5H_{10} contain the same functional group.

Draw the displayed formula of pent-1-ene.

Draw the structures of the pair of stereoisomers and give their full IUPAC names.

Explain the origin of the stereoisomerism shown.

(5)

(c) The rates of hydrolysis of two chloroalkanes can be investigated by adding aqueous silver nitrate to the chloroalkanes. During the hydrolysis reactions, chloride ions are liberated slowly. Precipitates of silver chloride are formed.

Outline a method to compare the rate of hydrolysis of 1-chlorobutane with that of 2-chlorobutane. State how the method would ensure a fair test.

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_____

_____

_____

_____

_____

_____

(4)

(Total 17 marks)

Q25.

Central heating fuel, obtained by the fractional distillation of crude oil, contains saturated hydrocarbons with the molecular formula $C_{16}H_{34}$

(a) Give the meaning of the terms **saturated** and **hydrocarbon** as applied to saturated hydrocarbons.

Saturated _____

_____

Hydrocarbon _____

_____

(2)

(b) If the boiler for a central heating system is faulty, a poisonous gas may be produced during the combustion of $C_{16}H_{34}$

Write an equation for the reaction that forms this poisonous gas and one other product only.

_____

(1)

(c) Explain why the sulfur compounds found in crude oil should be removed from the fractions before they are used for central heating fuel.

_____

_____

_____

_____

_____

(2)

(d) A hydrocarbon $C_{16}H_{34}$ can be cracked to form C_8H_{18}, ethene and propene.

(i) Write an equation to show this cracking reaction.

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_____

(1)

(ii) Suggest **one** important substance manufactured on a large scale from propene.

_____

(1)

(iii) Draw the **displayed formula** of the functional group isomer of propene.

(1)

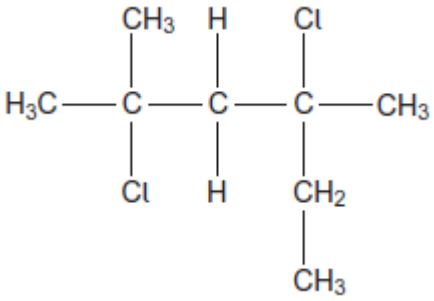
(e) There are many structural isomers with the molecular formula C_8H_{18}

Draw the structure of 2,3,3-trimethylpentane.

(1)

(f) A compound C_8H_{18} reacts with chlorine to give several haloalkanes.

Give the IUPAC name of the following haloalkane.



_____

(1)

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(Total 10 marks)

Q26.

Some oil-fired heaters use paraffin as a fuel.
One of the compounds in paraffin is the straight-chain alkane, dodecane ($C_{12}H_{26}$).

(a) Give the name of the substance from which paraffin is obtained.
State the name of the process used to obtain paraffin from this substance.

Substance _____

Process _____

(2)

(b) The combustion of dodecane produces several products.

Write an equation for the **incomplete** combustion of dodecane to produce gaseous products only.

_____

(1)

(c) Oxides of nitrogen are also produced during the combustion of paraffin in air.

(i) Explain how these oxides of nitrogen are formed.

_____

_____

_____

_____

(2)

(ii) Write an equation to show how nitrogen monoxide in the air is converted into nitrogen dioxide.

_____

(1)

(iii) Nitric acid (HNO_3) contributes to acidity in rainwater.

Deduce an equation to show how nitrogen dioxide reacts with oxygen and water to form nitric acid.

_____

(1)

(d) Dodecane ($C_{12}H_{26}$) can be cracked to form other compounds.

(i) Give the general formula for the homologous series that contains dodecane.

_____

(1)

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(ii) Write an equation for the cracking of one molecule of dodecane into equal amounts of two different molecules each containing the same number of carbon atoms.
State the empirical formula of the straight-chain alkane that is formed.
Name the catalyst used in this reaction.

Equation _____

Empirical formula of alkane _____

Catalyst _____

_____

(3)

(iii) Explain why the melting point of dodecane is higher than the melting point of the straight-chain alkane produced by cracking dodecane.

_____

_____

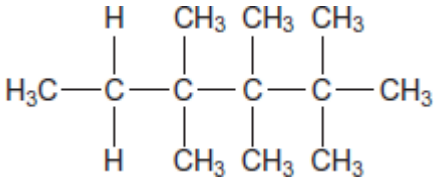
_____

_____

_____

(2)

(e) Give the IUPAC name for the following compound and state the type of structural isomerism shown by this compound and dodecane.



IUPAC name _____

Type of structural isomerism _____

(2)

(f) Dodecane can be converted into halododecanes.

Deduce the formula of a substance that could be reacted with dodecane to produce 1-chlorododecane and hydrogen chloride only.

_____

(1)

(Total 16 marks)

Q27.

The following table gives the names and structures of some structural isomers with the molecular formula C_5H_{10}.

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	Name of isomer	Structure
Isomer **1**	pent-2-ene	$CH_3CH = CHCH_2CH_3$
Isomer **2**	cyclopentane	
Isomer **3**	3-methylbut-1-ene	$(CH_3)_2CHCH = CH_2$
Isomer **4**	2-methylbut-2-ene	$(CH_3)_2C = CHCH_3$
Isomer **5**	2-methylbut-1-ene	$H_2C = C(CH_3)CH_2CH_3$

(a) Isomer **1** exists as E and Z stereoisomers.

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

_____

_____

_____

_____

_____

(2)

(ii) Draw the structure of the E stereoisomer of Isomer **1**.

(1)

(b) A chemical test can be used to distinguish between separate samples of Isomer **1** and Isomer **2**.

Identify a suitable reagent for the test.
State what you would observe with Isomer **1** and with Isomer **2**.

Reagent _____

Observation with Isomer **1** _____

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_____

Observation with Isomer **2** _____

_____

(3)

(c) Use **Table A** on the Data Sheet when answering this question.
Isomer **3** and Isomer **4** have similar structures.

(i) State the infrared absorption range that shows that Isomer **3** and Isomer **4** contain the same functional group.

_____

_____

(1)

(ii) State **one** way that the infrared spectrum of Isomer 3 is different from the infrared spectrum of Isomer **4**.

_____

_____

_____

(1)

(d) Two alcohols are formed by the hydration of Isomer **4**.

Draw the **displayed formula** for the alcohol formed that is oxidised readily by acidified potassium dichromate(VI).

(1)

(e) Isomer **4** reacts with hydrogen bromide to give two structurally isomeric bromoalkanes.

(i) Name and outline a mechanism for the reaction of Isomer **4** with hydrogen bromide to give 2-bromo-2-methylbutane as the major product.

$$(CH_3)_2C = CHCH_3 + HBr \longrightarrow (CH_3)_2CBrCH_2CH_3$$

Name of mechanism _____

Mechanism

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(5)

(ii) The minor product in this reaction mixture is 2-bromo-3-methylbutane.

Explain why this bromoalkane is formed as a minor product.

_____

_____

_____

_____

_____

(2)

(f) Name and outline a mechanism for the following reaction to form Isomer **5**.
State the role of the hydroxide ion in this reaction.

$(CH_3)_2CBrCH_2CH_3 + KOH \longrightarrow H_2C = C(CH_3)CH_2CH_3 + KBr + H_2O$

Name of mechanism _____

Mechanism

Role of hydroxide ion _____

(5)

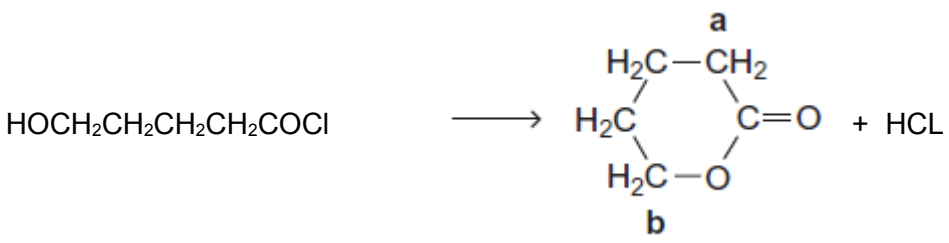
(Total 21 marks)

Q28.

This question is about some isomers of $C_5H_8O_2$

(a) Compound **H** is a cyclic ester that can be prepared as shown.

On the structure of **H**, two of the carbon atoms are labelled.



H

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(i) Name and outline a mechanism for this reaction.

Use **Table C** on the Data Sheet to give the ^{13}C n.m.r. δ value for the carbon atom labelled **a** and the δ value for the carbon atom labelled **b**.

(7)

(ii) $HOCH_2CH_2CH_2CH_2COCl$ can also react to form a polyester in a mechanism similar to that in part (i).

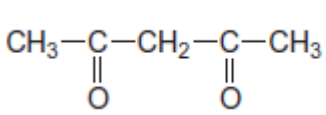
Draw the repeating unit of the polyester and name the type of polymerisation involved.

(2)

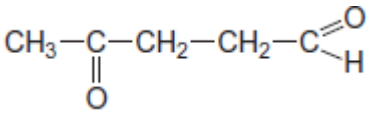
(b) State how you could distinguish between compounds **J** and **K** by a simple test-tube reaction.

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State how you could distinguish between **J** and **K** by giving the number of peaks in the ^{1}H n.m.r. spectrum of each compound.



J



K

_____

_____

_____

_____

_____

_____

_____

_____

(5)

(c) Draw the structure of each of the following isomers of $C_5H_8O_2$
Label each structure you draw with the correct letter **L**, **M**, **N**, **P** or **Q**.

L is methyl 2-methylpropenoate.

M is an ester that shows E-Z stereoisomerism.

N is a carboxylic acid with a branched carbon chain and does **not** show stereoisomerism.

P is an optically active carboxylic acid.

Q is a cyclic compound that contains a ketone group and has only two peaks in its ^{1}H n.m.r. spectrum.

(5)
(Total 19 marks)

Q29.

(a) The hydrocarbon but-1-ene (C_4H_8) is a member of the homologous series of alkenes.
But-1-ene has structural isomers.

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(i) State the meaning of the term *structural isomers*.

_____

_____

_____

_____

(2)

(ii) Give the IUPAC name of the **position** isomer of but-1-ene.

_____

(1)

(iii) Give the IUPAC name of the **chain** isomer of but-1-ene.

_____

(1)

(iv) Draw the displayed formula of a **functional group** isomer of but-1-ene.

(1)

(b) But-1-ene burns in a limited supply of air to produce a solid and water only.

(i) Write an equation for this reaction.

_____

(1)

(ii) State **one** hazard associated with the solid product in part (b)(i).

_____

(1)

(c) One mole of compound **Y** is cracked to produce two moles of ethene, one mole of but-1-ene and one mole of octane (C_8H_{18}) only.

(i) Deduce the molecular formula of **Y**.

_____

(1)

(ii) Other than cracking, give **one** common use of **Y**.

_____

(1)

(d) In cars fitted with catalytic converters, unburned octane reacts with nitrogen monoxide to form carbon dioxide, water and nitrogen only.

(i) Write an equation for this reaction.

_____

(1)

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

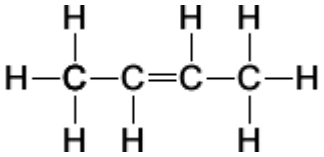
_____

(1)

(Total 11 marks)

Q30.

Compound **X** is shown below. It is a member of a homologous series of hydrocarbons.



(a) (i) Deduce the general formula of the homologous series that contains **X**.

_____

(1)

(ii) Name a process used to obtain a sample of **X** from a mixture containing other members of the same homologous series.

_____

(1)

(b) There are several isomers of **X**.

(i) Give the IUPAC name of the position isomer of **X**.

_____

(1)

(ii) Draw the structure of a functional group isomer of **X**.

(1)

(c) At high temperatures, one molecule of $C_{15}H_{32}$ can be converted into two molecules of **X** and one molecule of another compound.

(i) Write an equation for this reaction.

_____

(1)

(ii) State the name of the process used to obtain a high yield of **X** from $C_{15}H_{32}$
Give **one** reason why this process is used in industry.

Name _____

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Reason _____

_____

(2)

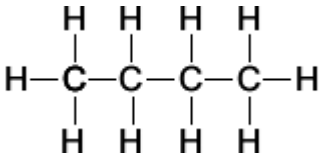
(iii) State why high temperatures are needed for this process.

_____

_____

(1)

(d) Compound **X** can be converted into compound **Y**.
Compound **Y** is shown below.



(i) Suggest the formula of a reagent that could be added to **X** in order to convert it into **Y**.

_____

(1)

(ii) Give **one** use of **Y**.

_____

(1)

(iii) Write an equation to show the reaction of **Y** in a limited supply of air to produce a solid and water only.

_____

(1)

(iv) When a sample of **Y**, contaminated with CH_3SH, is burned completely in air, a toxic gas is formed.
Identify this toxic gas and suggest a compound that could be used to remove the toxic gas from the products of combustion.

Toxic gas _____

Compound used to remove toxic gas _____

_____

(2)

(v) Suggest the name of the process that occurs when the toxic gas in part (d)(iv) is removed.

_____

(1)

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(e) Explain why the boiling points of **X** and **Y** are similar.

_____

_____

_____

_____

(2)

(Total 16 marks)

Q31.

Hexane (C_6H_{14}) is a member of the homologous series of alkanes.

(a) (i) Name the raw material from which hexane is obtained.

_____

(1)

(ii) Name the process used to obtain hexane from this raw material.

_____

(1)

(b) C_6H_{14} has structural isomers.

(i) Deduce the number of structural isomers with molecular formula C_6H_{14}

Write the number in this box. ☐

(Space for working)

(1)

(ii) State **one** type of structural isomerism shown by the isomers of C_6H_{14}

_____

(1)

(c) One molecule of an alkane **X** can be cracked to form one molecule of hexane and two molecules of propene.

(i) Deduce the molecular formula of **X**.

_____

_____

(1)

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(ii) State the type of cracking that produces a high percentage of alkenes. State the conditions needed for this type of cracking.

Type of cracking _____

Conditions _____

_____

(2)

(iii) Explain the main economic reason why alkanes are cracked.

_____

_____

(1)

(d) Hexane can react with chlorine under certain conditions as shown in the following equation.

$$C_6H_{14} + Cl_2 \longrightarrow C_6H_{13}Cl + HCl$$

(i) Both the products are hazardous. The organic product would be labelled 'flammable'.
Suggest the most suitable hazard warning for the other product.

_____

(1)

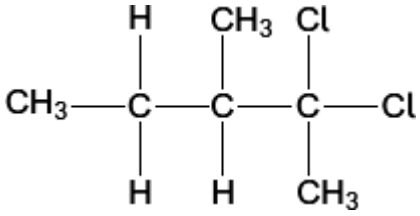
(ii) Calculate the percentage atom economy for the formation of $C_6H_{13}Cl$ (M_r = 120.5) in this reaction.

_____

_____

(1)

(e) A different chlorinated compound is shown below. Name this compound and state its empirical formula.



Name _____

Empirical formula _____

(2)

(Total 12 marks)

Q32.

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Pentane is a member of the alkane homologous series.

(a) Give the general formula for the homologous series of alkanes.

_____

(1)

(b) One of the structural isomers of pentane is 2,2-dimethylpropane.

Draw the displayed formula of 2,2-dimethylpropane.

State the type of structural isomerism shown.

_____

(2)

(c) A molecule of hydrocarbon **Y** can be thermally cracked to form one molecule of pentane and two molecules of ethene only.

Deduce the molecular formula of **Y**.

State why high temperatures are necessary for cracking reactions to occur.

Give **one** reason why thermal cracking reactions are carried out in industry.

_____

_____

_____

_____

_____

_____

(3)

(d) Write an equation for the incomplete combustion of pentane to form a solid pollutant.

Suggest why this solid pollutant is an environmental problem.

_____

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_____

_____

_____

(2)

(e) Pentane can react with chlorine as shown in the following equation.

$$C_5H_{12} + Cl_2 \rightarrow C_5H_{11}Cl + HCl$$

Calculate the percentage atom economy for the formation of $C_5H_{11}Cl$

Deduce how many straight-chain isomers of $C_5H_{11}Cl$ could be formed.

_____

_____

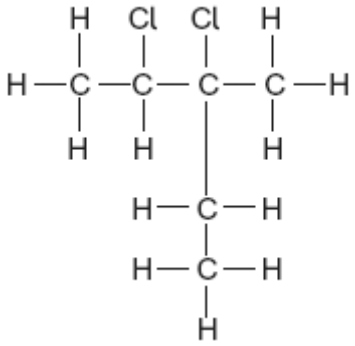
_____

_____

_____

(3)

(f) Consider the following compound.



Name this compound.

Deduce the empirical formula of this compound.

_____

_____

_____

_____

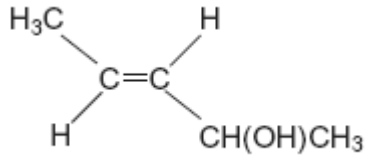
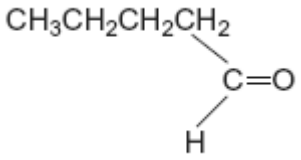
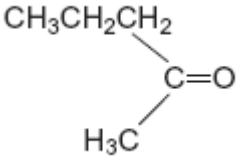
(2)

(Total 13 marks)

Q33.

The table below shows the structures of three isomers with the molecular formula $C_5H_{10}O$

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Isomer **1** 	(*E*)-pent-3-en-2-ol
Isomer **2** 	pentanal
Isomer **3** 	

(a) Complete the table by naming Isomer **3**.

(1)

(b) State the type of structural isomerism shown by these three isomers.

_____

(1)

(c) The compound (*Z*)-pent-3-en-2-ol is a stereoisomer of (*E*)-pent-3-en-2-ol.

(i) Draw the structure of (*Z*)-pent-3-en-2-ol.

(1)

(ii) Identify the feature of the double bond in (*E*)-pent-3-en-2-ol and that in (*Z*)-pent-3-en-2-ol that causes these two compounds to be stereoisomers.

_____

(1)

(d) A chemical test can be used to distinguish between separate samples of Isomer **2** and Isomer **3**.
Identify a suitable reagent for the test.
State what you would observe with Isomer **2** and with Isomer **3**.

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Test reagent

_____

Observation with Isomer **2**

_____

_____

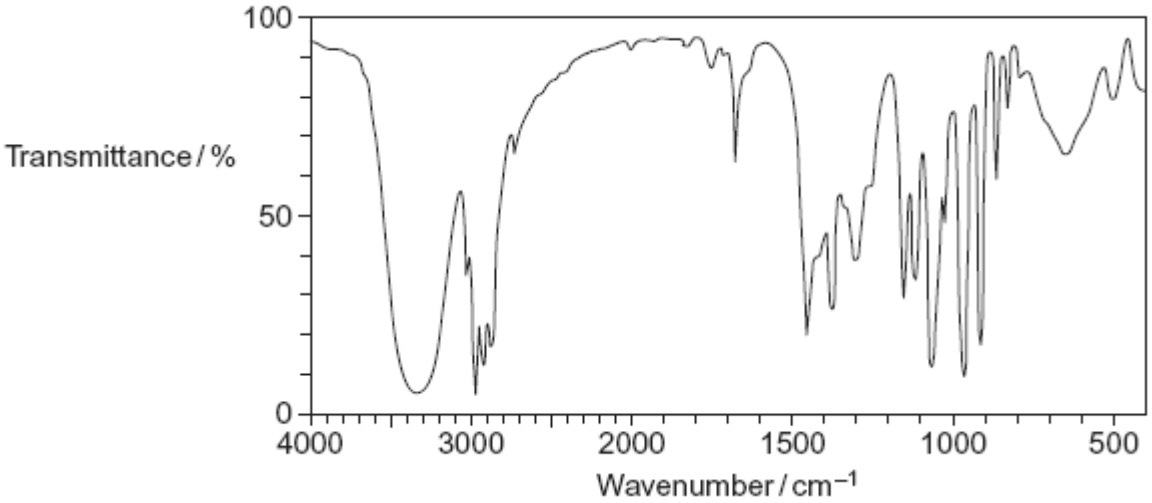
Observation with Isomer **3**

_____

_____

(3)

(e) The following is the infrared spectrum of one of the isomers **1**, **2** or **3**.



(i) Deduce which of the isomers (**1**, **2** or **3**) would give this infrared spectrum.
You may find it helpful to refer to **Table 1** on the Data Sheet.

_____

(1)

(ii) Identify two features of the infrared spectrum that support your deduction.
In each case, identify the functional group responsible.

Feature 1 and functional group _____

_____

_____

_____

Feature 2 and functional group _____

_____

_____

_____

(2)

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(Total 10 marks)

Q34.

Pent-1-ene is a member of the alkene homologous series.

(a) Pent-1-ene can be separated from other alkenes.

State the physical property of alkenes that allows them to be separated from a mixture by fractional distillation.

_____

(1)

(b) (i) State the meaning of the term *structural isomerism*.

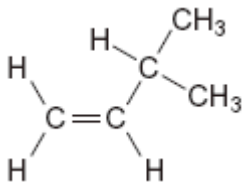
_____

_____

_____

(2)

(ii) Name the branched chain isomer of pent-1-ene shown below.



_____

(1)

(iii) Draw the structure of a functional group isomer of pent-1-ene.

(1)

(c) The cracking of one molecule of compound **X** produces pent-1-ene, ethene and butane in a 1:2:1 mol ratio.
Deduce the molecular formula of **X** and state a use for the ethene formed.

Molecular formula of **X** _____

_____

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Use of ethene _____

(2)

(Total 7 marks)

Q35.

Octane is the eighth member of the alkane homologous series.

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

_____

_____

_____

_____

(2)

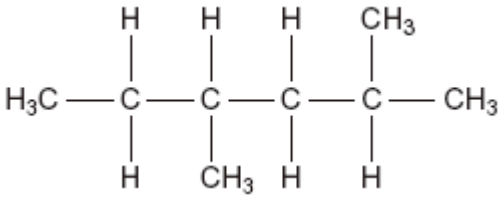
(b) Name a process used to separate octane from a mixture containing several different alkanes.

_____

_____

(1)

(c) The structure shown below is one of several structural isomers of octane.



Give the meaning of the term structural isomerism.
Name this isomer and state its empirical formula.

_____

_____

_____

_____

_____

_____

(4)

(d) Suggest why the branched chain isomer shown above has a lower boiling point than octane.

_____

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_____

_____

_____

(2)

(Total 9 marks)

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