F322: Chains, Energy and Resources
Basic Concepts

1. Some of the hydrocarbons in kerosene have the formula $C_{10}H_{22}$.

(i) What is the name of the straight chain hydrocarbon with the formula $C_{10}H_{22}$?

.....

[1]

(ii) Draw the skeletal formula of one branched chain isomer with the formula $C_{10}H_{22}$.

[1]

(iii) Explain why the straight chain isomer of $C_{10}H_{22}$ has a higher boiling point than any of its branched chain structural isomers.

.....

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[2]

(iv) Explain why the straight chain isomer of $C_{10}H_{22}$ is converted by the petroleum industry into its branched chain isomers.

.....

.....

[1]

[Total 5 marks]

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2. (i) In the past, hydrogen peroxide was manufactured by reacting barium peroxide, BaO_2, with ice-cold dilute sulfuric acid.

$$BaO_2(s) + H_2SO_4(aq) \rightarrow BaSO_4(s) + H_2O_2(aq)$$

This method required the disposal of poisonous barium compounds.

Calculate the atom economy for this manufacture of hydrogen peroxide from BaO_2.
Use the table of relative formula masses given below.

compound	relative formula mass
BaO_2	169.3
H_2SO_4	98.1
$BaSO_4$	233.4
H_2O_2	34.0

atom economy = ... %

[2]

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(ii) Nowadays, hydrogen peroxide is manufactured using hydrogen gas, oxygen from the air and a substance called anthraquinone.

stage 1 H_2 + anthraquinone → anthraquinol

stage 2 O_2 + anthraquinol → H_2O_2 + anthraquinone

Compare the manufacture of H_2O_2 from hydrogen and oxygen with the manufacture from barium peroxide described in (i).

Explain the advantages of the manufacture of H_2O_2 from hydrogen and oxygen.

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[3]

[Total 5 marks]

3. The 'curly arrows' model is used in reaction mechanisms to show the movement of electron pairs during chemical reactions.

Choose a reaction mechanism that you have studied involving the curly arrow model.

Name and describe your chosen reaction mechanism.

In your answer, include:

- an example of the reaction with the chosen mechanism,
- the type of bond fission that occurs,
- relevant dipoles.

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.....

[Total 6 marks]

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4. Draw the skeletal formula for 2-methylpentan-3-ol.

[Total 1 mark]

5. Butan-2-ol and 2-methylpropan-2-ol are structural isomers.

(i) What is meant by the term *structural isomer*?

.....

.....

.....

[1]

(ii) Draw another structural isomer of these two alcohols.

[1]

[Total 2 marks]

6. Crude oil is a source of hydrocarbons which can be used as fuels or for processing into petrochemicals.

Octane, C_8H_{18}, is one of the alkanes present in petrol.

Carbon dioxide is formed during the complete combustion of octane.

$$C_8H_{18} + 12½O_2 \rightarrow 8CO_2 + 9H_2O$$

What is the general formula for an alkane?

.....

[Total 1 mark]

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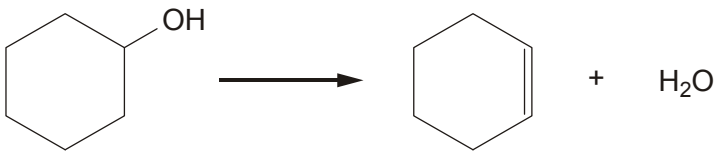
7. Oil companies process hydrocarbons, such as octane, into branched and cyclic hydrocarbons that promote efficient combustion in petrol.

Draw the skeletal formulae of a branched hydrocarbon and a cyclic hydrocarbon, each containing eight carbon atoms.

[Total 2 marks]

8. Alkenes can be prepared by the dehydration of alcohols with an acid catalyst. Cyclohexene can be prepared by the dehydration of cyclohexanol, shown below.



A student reacted 7.65 g of cyclohexanol, $C_6H_{12}O$, and obtained 0.0268 mol of cyclohexene.

(i) What is the molecular formula of cyclohexene?

.....

[1]

(ii) Calculate the percentage yield of cyclohexene.

answer = ... %

[3]

[Total 4 marks]

9. Percentage yield has been used for many years to measure the 'success' of a reaction. Recently, chemists have turned their thoughts also to the atom economy of a reaction.

(i) Explain the term *atom economy*.

.....

.....

[1]

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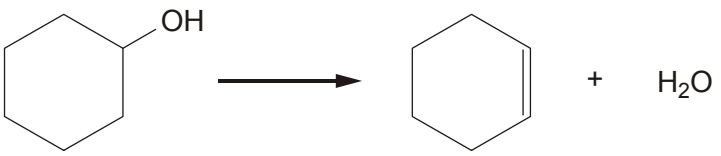
(ii) Alkenes can be prepared by the dehydration of alcohols with an acid catalyst. Cyclohexene can be prepared by the dehydration of cyclohexanol, shown below.



Cyclohexene can also be prepared by the reaction below.

Explain why the atom economy of this cyclohexene preparation is higher than that from cyclohexanol.

.....

.....

.....

.....

[2]

[Total 3 marks]

10. In this question, you are asked to suggest structures for several organic compounds.

Compounds **F**, **G** and **H** are **unbranched** alkenes that are isomers, each with a relative molecular mass of 70.0.

Compounds **F** and **G** are *E*/*Z* stereoisomers.

Compound **H** is a structural isomer of compounds **F** and **G**.

- Explain what is meant by the terms *structural isomer* and *stereoisomer*.
- Explain why some alkenes have *E*/*Z* isomerism.
- Analyse this information to suggest possible structures for compounds **F**, **G** and **H**.

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In your answer you should make clear how each structure fits with the information given above.

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[Total 11 marks]

11. Predict the molecular formula of an alkane with 13 carbon atoms.

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[Total 1 mark]

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12. Bromobutane, $CH_3CH_2CH_2CH_2Br$, can be reacted with hot aqueous sodium hydroxide to prepare butan-1-ol.

$$CH_3CH_2CH_2CH_2Br + OH^- \rightarrow CH_3CH_2CH_2CH_2OH + Br^-$$

A student reacted 8.72 g of bromobutane with an excess of OH^-. The student produced 4.28 g of butan-1-ol.

(i) Calculate the amount, in mol, of $CH_3CH_2CH_2CH_2Br$ reacted.

$CH_3CH_2CH_2CH_2Br$, *M*r = 136.9

..... mol

[1]

(ii) Calculate the amount, in mol, of $CH_3CH_2CH_2CH_2OH$ produced.

..... mol

[2]

(iii) Calculate the percentage yield.

Quote your answer to **three** significant figures.

..... %

[1]

[Total 4 marks]

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13. But-1-ene is just one isomer with the molecular formula C_4H_8.

Using C_4H_8 as your example, describe and explain what is meant by structural isomerism and *cis-trans* isomerism.

Include diagrams in your answer.

In your answer you should make clear how each type of isomerism is related to structural features.

[Total 7 marks]

14. In this question, one mark is available for the quality of use and organisation of scientific terms.

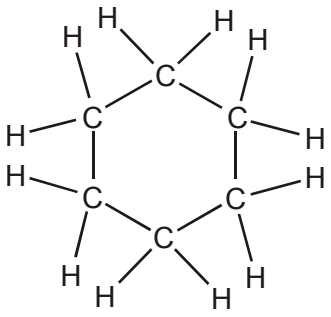
- Describe, with the aid of a suitable diagram, the formation of the π-bond in propene.
- State the shape, and an approximate value for the bond angles, around each carbon atom in propene.
- Describe, with the aid of a suitable example, why some alkenes show *cis-trans* isomerism.

[9]

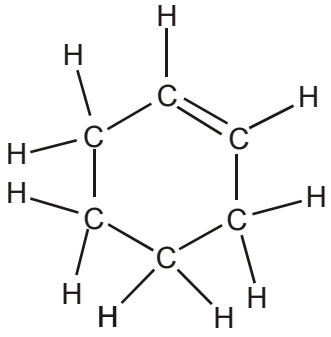
Quality of Written Communication [1]

[Total 10 marks]

15. Cylcohexane and cyclohexene are both cyclic hydrocarbons.



cyclohexane



cyclohexene

(i) What is the molecular formula of cyclohexene? .....

[1]

(ii) What is the empirical formula of cyclohexene? .....

[1]

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(iii) Calculate the percentage, by mass, of carbon in cyclohexene. Give your answer to **two** significant figures.

answer .....

[2]

[Total 4 marks]

16. Halogenoalkanes are used in the production of pharmaceuticals, polymers and flame retardants.

1-Bromo-2-methylpropane is used in the production of ibuprofen and can be prepared from the reaction between 2-methylpropan-1-ol and HBr.

$$(CH_3)_2CHCH_2OH + HBr \rightarrow (CH_3)_2CHCH_2Br + H_2O$$

A student reacted 4.44 g of 2-methylpropan-1-ol with an excess of HBr. The student produced 5.48 g of 1-bromo-2-methylpropane.

(i) Calculate the number of moles of $(CH_3)_2CHCH_2OH$ used.

answer …… mol

[2]

(ii) Calculate the number of moles of $(CH_3)_2CHCH_2Br$ collected.
$(CH_3)_2CHCH_2Br$, M_r =137

answer …… mol

[1]

(iii) Calculate the percentage yield. Quote your answer to three significant figures.

answer ……

[1]

[Total 4 marks]

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17. In this question, one mark is available for the quality of use and organisation of scientific terms.

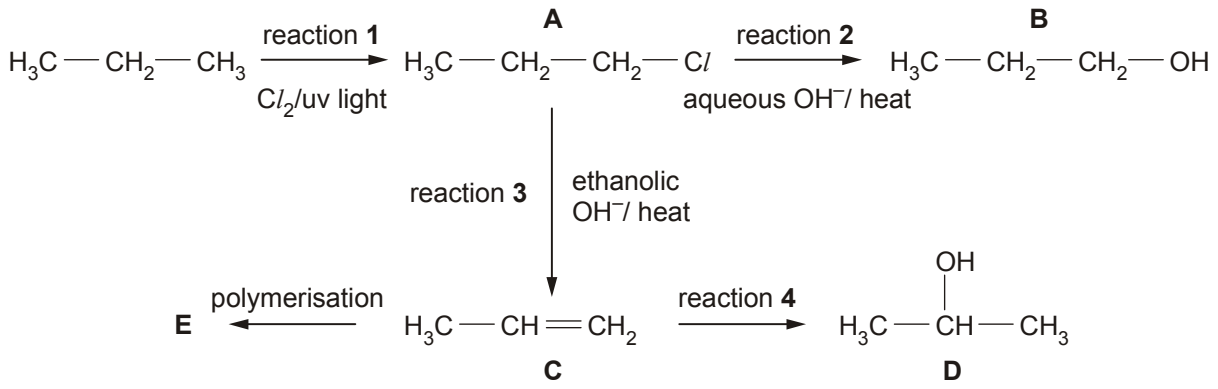
Name and give examples of the types of isomerism in compounds with formula C_4H_8. Explain how each type of isomerism arises.

[8]

Quality of Written Communication [1]

[Total 9 marks]

18. Propane, C_3H_8, is used in the reaction sequence shown below.



(a) The reaction sequence shows several important reaction mechanisms. Select from reactions **1** to **4**, the reaction that shows

(i) free radical substitution, reaction .....

[1]

(ii) electrophilic addition, reaction .....

[1]

(iii) elimination, reaction .....

[1]

(b) In reaction **2**, the aqueous OH^- acts as a nucleophile.

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

.....

[1]

(ii) Complete, with the aid of curly arrows, the mechanism involved in reaction **2**. Show any relevant dipoles.

$H_3C-CH_2-CH_2-Cl \longrightarrow H_3C-CH_2-CH_2-OH$ + ...

OH^-

[4]

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(c) Compounds **B** and **D** are structural isomers of each other.

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

.....

.....

[2]

(ii) Draw the skeletal formulae of compounds **B** and **D**.

Compound **B**	Compound **D**

[2]

(d) Compound **C** can be polymerised to form compound **E**.

(i) State the type of polymerisation. .....

[1]

(ii) Name compound **E**. .....

[1]

(iii) Draw a section of compound **E**. Show **two** repeat units.

[1]

[Total 15 marks]

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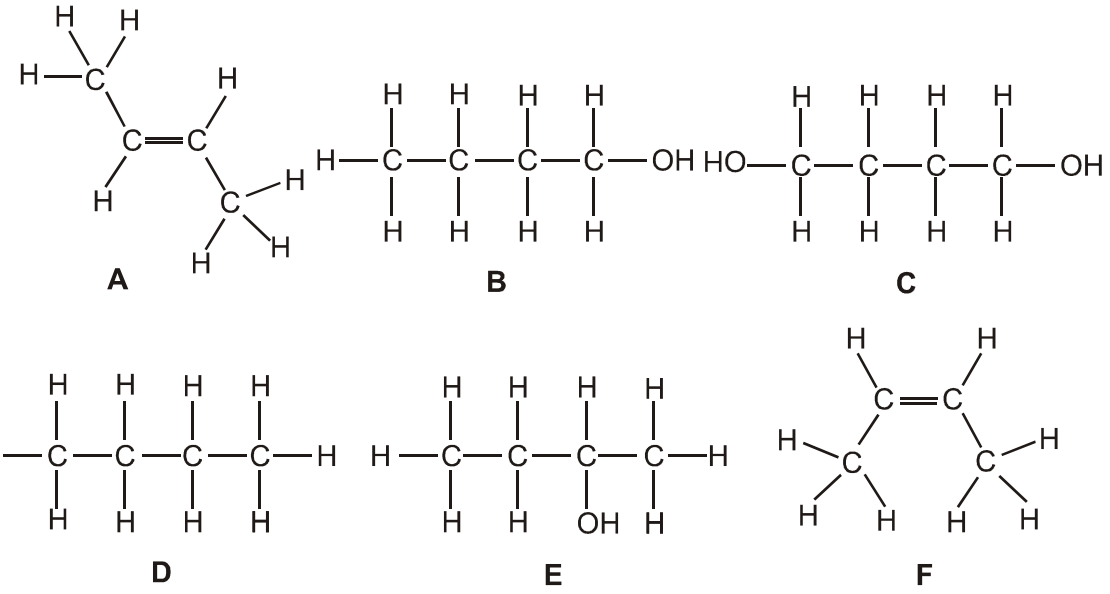
19. This question is about the compounds **A-F** below.



(a) Answer the following questions by referring to the compounds **A-F**.

(i) What is the molecular formula of compound **D**?

.....

[1]

(ii) What is the empirical formula of compound **C**?

.....

[1]

(iii) Which two compounds are structural isomers of each other?

..... and .....

[1]

(iv) Which two compounds are *cis-trans* isomers of each other?

..... and .....

[1]

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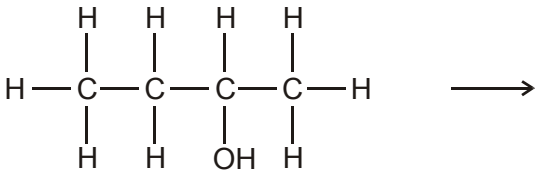
(b) Compound **E** can be dehydrated to form compound **A**. Complete a balanced equation for this reaction.



[1]

(c) Compound **C** can be dehydrated to form a new compound, **G**, with the molecular formula, C_4H_6. Suggest a structural formula and a name for **G**.

name .....

[2]

[Total 7 marks]

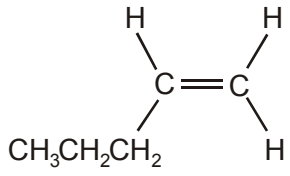
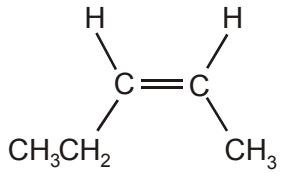
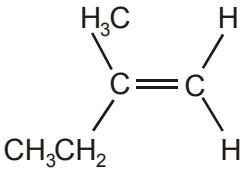
20. (a) Many organic molecules show structural isomerism. State what is meant by the term *structural isomerism*.

.....

.....

[2]

(b) Isomers **1**, **2** and **3**, shown below, are unsaturated structural isomers of C_5H_{10}.

 isomer **1**	 isomer **2**	 isomer **3**

(i) Complete the boxes by drawing two other unsaturated structural isomers of C_5H_{10}.

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[2]

(ii) Name isomer **3**.

.....

[1]

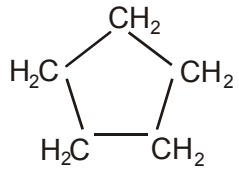
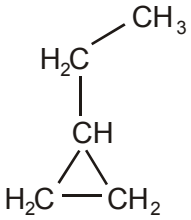
(iii) Draw the skeletal formula of isomer **2**.

[1]

[Total 6 marks]

21. There are several **cycloalkanes** that are structural isomers of C_5H_{10}.

(i) Complete the boxes by drawing two other structural isomers of C_5H_{10} that are also **cycloalkanes**.

			
Isomer **L**		**ethylcyclopropane**	

[2]

(ii) Name isomer **L** drawn in (i).

.....

[1]

(iii) Draw the skeletal formula of isomer **L**.

[1]

[Total 4 marks]

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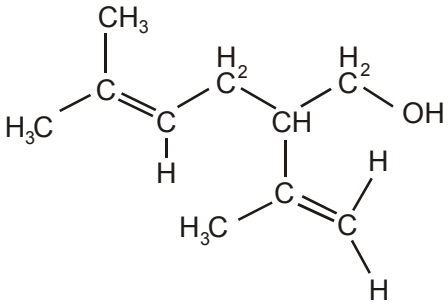
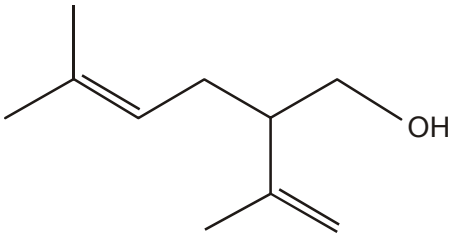
22. Lavandulol, $C_{10}H_{18}O$, is a fragrant oil which is found in lavender. The structural and the skeletal formulae of lavandulol are shown below.



structural formula



skeletal formula

(a) (i) Identify **two** different functional groups in lavandulol.

..... and .....

[2]

(ii) Why does lavandulol **not** have *cis-trans* isomerism?

.....

.....

[1]

(b) Lavandulol, $C_{10}H_{18}O$, also reacts with bromine to form a saturated organic product.

State what you would see in this reaction and deduce the molecular formula of the organic product.

observation .....

[1]

molecular formula .....

[2]

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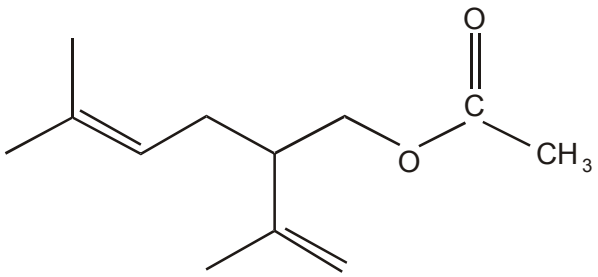
(c) Lavandulol could be converted into an ester **X**, which is also found in lavender oil.



ester **X**

State a reagent and a catalyst that could be used to form ester **X** from lavandulol.

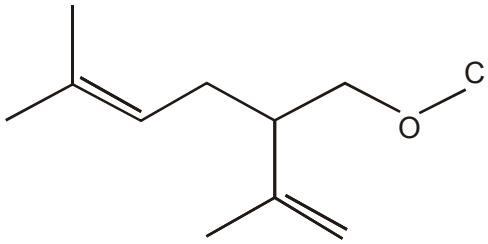
reagent .....

[1]

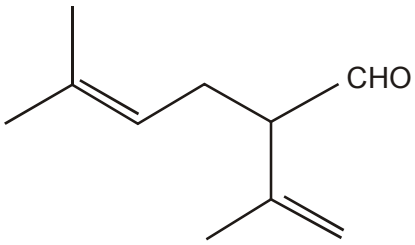
catalyst .....

[1]

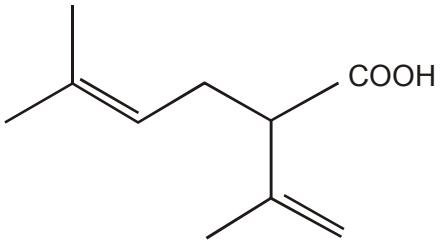
(d) Lavanduloi can be oxidised to produce either compound **Y** or compound **Z**.



lavandulol
$C_{10}H_{18}O$



compound **Y**
$C_{10}H_{16}O$



compound **Z**
$C_{10}H_{16}O_2$

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(i) Write a balanced equation for the oxidation of lavandulol to produce compound **Z**. Use the molecular formulae given above and use [O] to represent the oxidising agent.

.....

[2]

(ii) An infra-red spectrum of either compound **Y** or compound **Z** was obtained and was found to contain an absorption between 1680 – 1750 cm^{-1}. However, there was no broad absorption between 2500 – 3300 cm^{-1}.

By referring to your *Data Sheet*, use this information to deduce whether the infra-red spectrum was of compound **Y** or of compound **Z**. Show your reasoning.

The infra-red spectrum was of compound ..... because .....

.....

.....

.....

[2]

[Total 12 marks]

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