Candidate surname

Other names

Pearson Edexcel
International
Advanced Level

Centre Number

Candidate Number

Tuesday 12 January 2021

Morning (Time: 1 hour 30 minutes)

Paper Reference **WCH11/01**

Chemistry

International Advanced Subsidiary/Advanced Level
Unit 1: Structure, Bonding and Introduction to
Organic Chemistry

You must have:
Scientific calculator, Ruler

Total Marks

Instructions

- Use **black** ink or **black** ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need*.
- Show all your working in calculations and include units where appropriate.

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question*.
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P 6 7 7 5 2 A 0 1 2 4

Pearson

Answer ALL questions. Write your answers in the spaces provided.

For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which of these compounds has the same empirical and molecular formulae?

☒ **A** C_2H_4

☒ **B** C_3H_8

☒ **C** C_4H_{10}

☒ **D** C_5H_{10}

(Total for Question 1 = 1 mark)

2 There are 6.02×10^{23} atoms in 0.25 mol of

☒ **A** He

☒ **B** H_2O

☒ **C** BH_3

☒ **D** CH_4

(Total for Question 2 = 1 mark)

3 Which aqueous solution has the **highest** concentration, in mol dm^{-3}, of chloride ions?

☒ **A** 0.1 g dm^{-3} HCl

☒ **B** 0.1 g dm^{-3} NaCl

☒ **C** 0.1 g dm^{-3} KCl

☒ **D** 0.1 g dm^{-3} BaCl$_2$

(Total for Question 3 = 1 mark)

4 Which conversion has the **lowest** percentage atom economy (by mass) for the formation of CaCl$_2$?

☒ **A** $Ca + Cl_2 \rightarrow CaCl_2$

☒ **B** $Ca + 2HCl \rightarrow CaCl_2 + H_2$

☒ **C** $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

☒ **D** $CaCO_3 + 2NaCl \rightarrow CaCl_2 + Na_2CO_3$

(Total for Question 4 = 1 mark)

5 Which of these atoms has the most neutrons?

☒ **A** $^{115}_{49}\text{In}$

☒ **B** $^{124}_{50}\text{Sn}$

☒ **C** $^{123}_{51}\text{Sb}$

☒ **D** $^{124}_{52}\text{Te}$

(Total for Question 5 = 1 mark)

6 A p-block element in **Period 3** of the Periodic Table reacts to form an ionic compound.

What could be the electronic configuration of the **ion** formed by this element?

☒ **A** $1s^22s^22p^63s^2$

☒ **B** $1s^22s^22p^63s^23p^6$

☒ **C** $1s^22s^22p^63s^23p^63d^{10}$

☒ **D** $1s^22s^22p^63s^23p^63d^{10}4s^24p^6$

(Total for Question 6 = 1 mark)

7 The **Period 2** element with the **highest** melting temperature is

☒ **A** aluminium

☒ **B** boron

☒ **C** carbon

☒ **D** silicon

(Total for Question 7 = 1 mark)

8 Which of these has the **greatest** electrical conductivity?

☒ **A** $SF_6(g)$

☒ **B** $H_2O(l)$

☒ **C** $Hg(l)$

☒ **D** $Na_2O(s)$

(Total for Question 8 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

9 Which of these ions has the **greatest** ionic radius?

☒ **A** N^{3-}

☒ **B** F^-

☒ **C** Na^+

☒ **D** Al^{3+}

(Total for Question 9 = 1 mark)

10 Which of these ions has the **greatest** polarising power?

☒ **A** S^{2-}

☒ **B** Cl^-

☒ **C** K^+

☒ **D** Ca^{2+}

(Total for Question 10 = 1 mark)

11 Which of these does **not** have a structure formed by a giant lattice of carbon atoms?

☒ **A** C_{60} fullerene

☒ **B** diamond

☒ **C** graphene

☒ **D** graphite

(Total for Question 11 = 1 mark)

12 Which of these molecules is the **most** polar?

☒ **A** HF

☒ **B** OF_2

☒ **C** BF_3

☒ **D** CF_4

(Total for Question 12 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

13 A substance is labelled with the hazard symbol shown.

What is the meaning of this symbol?

☒ **A** gloves must be worn

☒ **B** corrosive

☒ **C** do not store with flammable substances

☒ **D** oxidising

(Total for Question 13 = 1 mark)

14 What is the IUPAC name of this alkane?
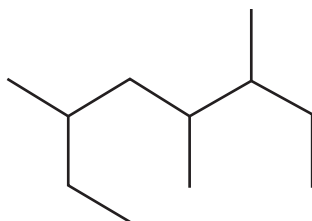
☒ **A** 2-ethyl-4,5-dimethylheptane

☒ **B** 6-ethyl-3,4-dimethylheptane

☒ **C** 3,4,6-trimethyloctane

☒ **D** 3,5,6-trimethyloctane

(Total for Question 14 = 1 mark)

15 Petrol, bioethanol and hydrogen are fuels.

All three of these fuels

☒ **A** burn to produce greenhouse gases

☒ **B** are overall carbon neutral

☒ **C** are overall sustainable

☒ **D** biodegrade rapidly

(Total for Question 15 = 1 mark)

16 Cyclopentane undergoes free radical substitution with bromine.

(a) Which of these is an overall equation for this reaction?

(1)

- ☒ **A** $C_5H_8 + Br_2 \rightarrow C_5H_8Br_2$
- ☒ **B** $C_5H_{10} + Br_2 \rightarrow C_5H_{10}Br_2$
- ☒ **C** $C_5H_{10} + Br_2 \rightarrow C_5H_8Br_2 + H_2$
- ☒ **D** $C_5H_{10} + Br_2 \rightarrow C_5H_9Br + HBr$

(b) Which statement is **not** correct about this reaction system?

(1)

- ☒ **A** only the initiation step involves homolytic bond fission
- ☒ **B** only some bromine is converted to free radicals in the initiation step
- ☒ **C** propagation forms more product than termination
- ☒ **D** further substitution reactions are likely to occur
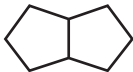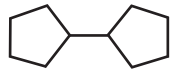
(c) Which free radical is **least** likely to form in a propagation step in this reaction system?

(1)

- ☒ **A** $C_5H_9^\bullet$
- ☒ **B** $Br^\bullet$
- ☒ **C** $C_5H_8Br^\bullet$
- ☒ **D** $H^\bullet$

(d) Which alkane could be formed in a termination step in this reaction system?

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 16 = 4 marks)

Use this space for any rough working. Anything you write in this space will gain no credit.

17 Which of these is **not** a way of limiting global problems caused by polymer disposal?

⊠ **A** developing biodegradable polymers

⊠ **B** exporting polymer waste

⊠ **C** removing toxic waste gases produced by the incineration of polymers

⊠ **D** reusing products made from polymers

(Total for Question 17 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

Answer ALL the questions. Write your answers in the spaces provided.

18 This question is about the element sulfur.

(a) Complete the diagram to show the electronic configuration for a sulfur atom in the ground state.
Include labels for each subshell.

(2)

Energy

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$\uparrow\downarrow$

1s
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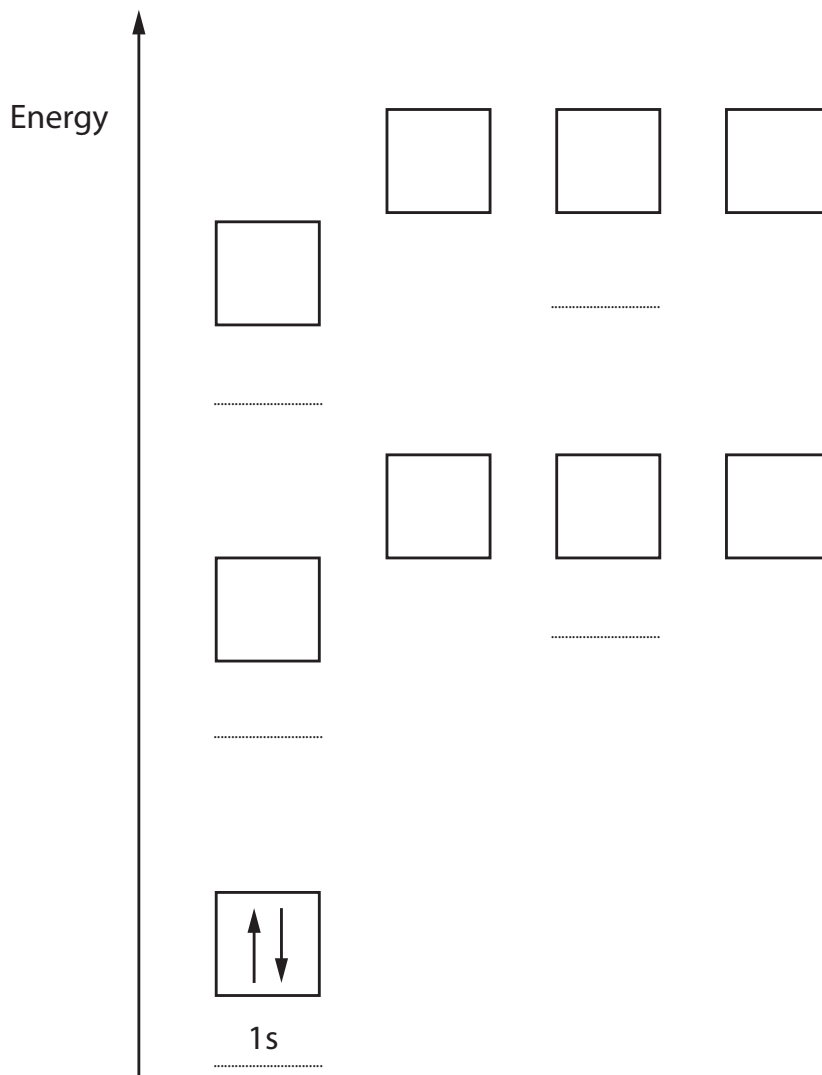
(b) Write an equation for the **first** ionisation energy of sulfur.
Include state symbols.

(2)

P67752A0824

(c) Explain why the first ionisation energy of sulfur is less than the first ionisation energies of **both** phosphorus and chlorine.

(3)

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(d) A sample of sulfur contains four isotopes.

Isotope	^{32}S	^{33}S	^{34}S	^{36}S
Percentage abundance	94.88	0.83	4.27	0.02

(i) State what is meant by the term **isotopes**, in terms of subatomic particles.

(2)

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(ii) Calculate the relative atomic mass of sulfur in this sample.

Give your answer to **two** decimal places.

(2)

(e) The mass spectrum of a sample of sulfur with ^{32}S as the only isotope is shown.
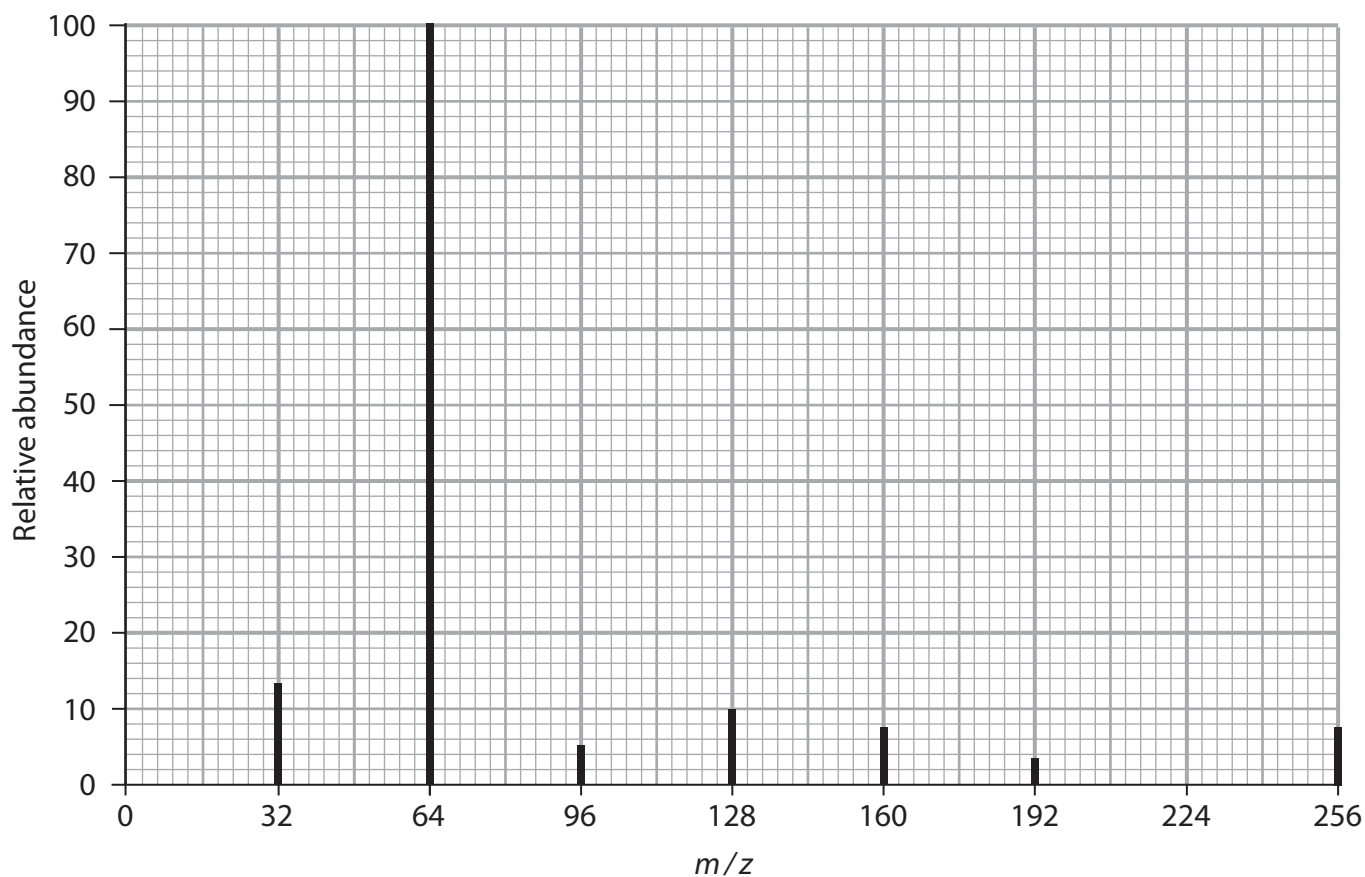
(i) Calculate the number of sulfur atoms in the molecular ion.

You **must** show your working.

(1)

(ii) Suggest the **formula** of the **most stable ion** shown by this spectrum.

(2)

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(Total for Question 18 = 14 marks)

19 This question is about the structure and bonding of Group 5 chlorides.

(a) Nitrogen trichloride, NCl_3, has a molecular structure.

The displayed formula of a molecule of NCl_3 is shown.
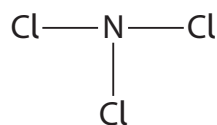
$$Cl\text{——}N\text{——}Cl$$
$$|$$
$$Cl$$

Complete the table for this molecule.

(3)

Number of bond pairs around N atom	
Number of lone pairs around N atom	
Cl-N-Cl bond angle	
Name of shape of molecule	

(b) Under standard conditions, phosphorus(V) chloride (PCl_5) is a solid made up of PCl_4^+ cations and PCl_6^- anions.

Antimony(V) chloride ($SbCl_5$) is a liquid made up of $SbCl_5$ molecules.

(i) Explain why PCl_5 has a higher melting temperature than $SbCl_5$.

(2)

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(ii) Draw a dot-and-cross diagram to show the bonding in a molecule of $SbCl_5$.

Use dots (•) to represent the Sb electrons, and crosses (**x**) to represent the Cl electrons. Show outer electrons only.

(2)

(c) At low temperatures, $SbCl_5$ converts to Sb_2Cl_{10} which contains dative covalent bonds.

(i) State what is meant by the term dative covalent bond.

(1)

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(ii) Complete the diagram to show the dative covalent bonds in Sb_2Cl_{10}.

(1)
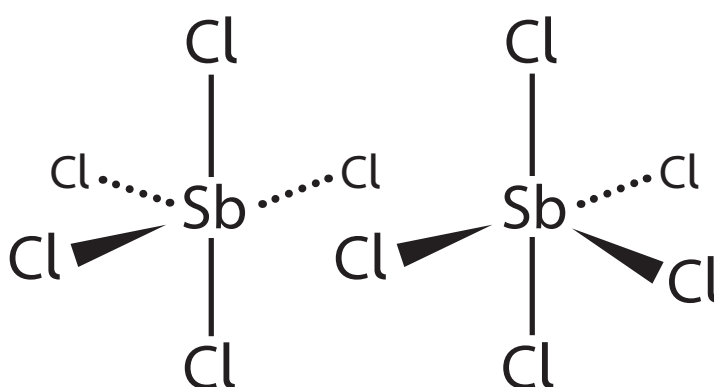
(d) Arsenic also forms a pentachloride with the formula $AsCl_5$.

Give **one** possible reason why nitrogen is the only Group 5 element that does **not** form a pentachloride.

(1)

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(Total for Question 19 = 10 marks)

20 This question is about the reactions of propene.
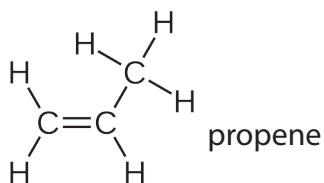
propene

(a) Write an equation for the incomplete combustion of **one mole** of propene to form carbon dioxide, carbon monoxide, carbon and water as the only products.
Include state symbols.

(2)

(b) State **one** similarity and **one** difference that would be **seen** when propene is mixed with separate samples of acidified potassium manganate(VII) solution and of bromine water.

(2)

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(c) Propene reacts by addition polymerisation to form poly(propene).

Draw the structure of poly(propene), showing **two** repeat units.

(1)

(d) Propene reacts with bromine monochloride, BrCl, to form
1-bromo-2-chloropropane as the major product.

(i) Complete the diagram of bromine monochloride to show the dipole.

(1)

Br ——— Cl

(ii) Draw the mechanism for the formation of 1-bromo-2-chloropropane in
this reaction.
Include curly arrows, and relevant lone pairs.

(3)

P 6 7 7 5 2 A 0 1 5 2 4

(e) Propene reacts with steam in the presence of an acid catalyst to form a mixture of the alcohols propan-1-ol and propan-2-ol.

Complete the mechanism for the formation of propan-2-ol, by adding curly arrows.
Include the species formed in the final step.

(3)
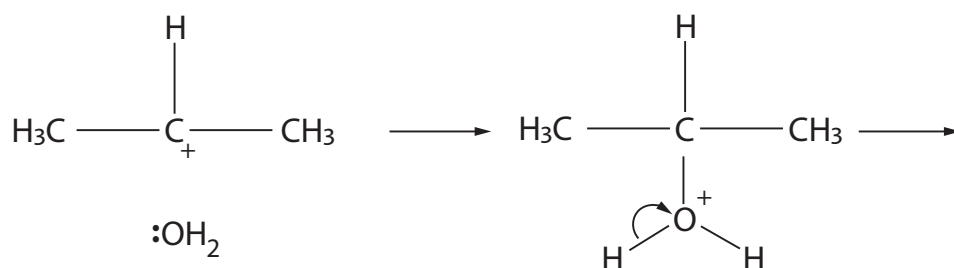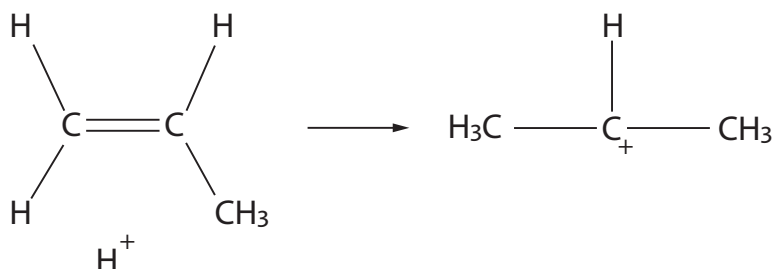
(Total for Question 20 = 12 marks)

21 This question is about the production of squalane, a liquid alkane which occurs naturally in human skin and is used in cosmetics.

squalane

(a) Suggest **two** properties that make squalane useful in cosmetics.

(2)

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....

(b) Give the **molecular** formula of squalane.

(1)

....

(c) Squalane can be produced from squalene, an alkene present in shark liver oil, by reaction with hydrogen gas in the presence of a suitable catalyst.

(i) Give the name of a suitable catalyst for the hydrogenation of squalene.

(1)

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(ii) Squalane used in cosmetic products must contain no more than 0.2 ppm by mass of catalyst.

Calculate the maximum permitted mass of catalyst in a product containing 50 g of squalane.

(1)

(iii) A reactor at 200°C contains 8500 mol of liquid squalene, and hydrogen gas at a pressure of 4.0×10^5 Pa.

Under these conditions, the complete hydrogenation of squalene requires 500 m^3 of hydrogen gas.

Calculate the number of C=C bonds in one molecule of squalene.

You **must** show your working.

[$pV = nRT$ $R = 8.31$ J mol^{-1} K^{-1}]

(4)

(iv) Write the equation, using molecular formulae, for the complete hydrogenation of squalene to squalane.
State symbols are **not** required.

(1)

(d) Globally, 2.8 million dm^3 of squalene is used each year.
Traditionally squalene was obtained exclusively from shark liver oil, which is a mixture of liquids.

The liver of a shark yields 300 g of squalene.

(i) Suggest the name of a suitable technique to obtain squalene from shark liver oil.

(1)

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(ii) Calculate the minimum number of sharks that would be needed to produce 2.8 million dm^3 of squalene.

[Density of squalene = 0.86 g cm^{-3}]

(2)

(iii) Many large corporations now use squalane obtained entirely from plants.

Squalane can be obtained sustainably from corn starch with a yield of 23 % by mass.

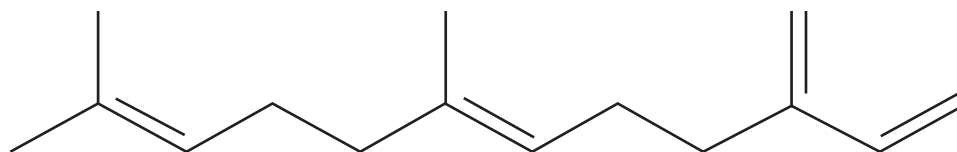The production of 1 tonne of corn starch requires 0.093 hectares of land.

Calculate the area of land, **in km²**, required to produce 2500 tonnes of squalane from corn starch.

[1 tonne = 1000 kg   1 hectare = 0.01 km^2]

(3)

(e) The *E*-isomer of beta-farnesene can also be obtained from corn starch.

E-beta-farnesene

(i) Explain why beta-farnesene exhibits geometric isomerism and has only two geometric isomers.

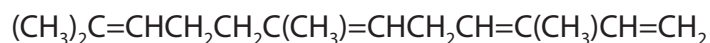You may label the structure and use this in your answer.

(2)

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(ii) Draw the **skeletal** formula of the geometric isomer of *E*-beta-farnesene, giving a reason why this is named the *Z*-isomer.

(2)

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(f) The compound alpha-farnesene, $C_{15}H_{24}$, is a structural isomer of beta-farnesene.

The structural formula of alpha-farnesene is

$$(CH_3)_2C=CHCH_2CH_2C(CH_3)=CHCH_2CH=C(CH_3)CH=CH_2$$

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

(2)

....

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(ii) State the number of **geometric** isomers of alpha-farnesene.

(1)

....

(iii) Complete the diagram to show another structural isomer of $C_{15}H_{24}$.

(1)
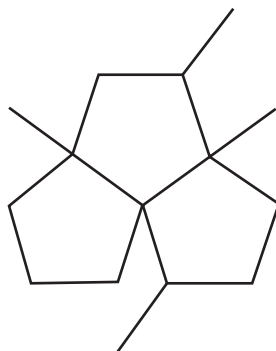
(Total for Question 21 = 24 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS