

Please check the examination details below before entering your candidate information

Candidate surname

Other names

**Pearson Edexcel**  
**International**  
**Advanced Level**

Centre Number

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Candidate Number

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**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 ►

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## SECTION A

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<sub>2</sub>H<sub>4</sub>
- B C<sub>3</sub>H<sub>8</sub>
- C C<sub>4</sub>H<sub>10</sub>
- D C<sub>5</sub>H<sub>10</sub>

(Total for Question 1 = 1 mark)

2 There are  $6.02 \times 10^{23}$  atoms in 0.25 mol of

- A He
- B H<sub>2</sub>O
- C BH<sub>3</sub>
- D CH<sub>4</sub>

(Total for Question 2 = 1 mark)

3 Which aqueous solution has the **highest** concentration, in mol dm<sup>-3</sup>, of chloride ions?

- A 0.1 g dm<sup>-3</sup> HCl
- B 0.1 g dm<sup>-3</sup> NaCl
- C 0.1 g dm<sup>-3</sup> KCl
- D 0.1 g dm<sup>-3</sup> BaCl<sub>2</sub>

(Total for Question 3 = 1 mark)

4 Which conversion has the **lowest** percentage atom economy (by mass) for the formation of CaCl<sub>2</sub>?

- A  $\text{Ca} + \text{Cl}_2 \rightarrow \text{CaCl}_2$
- B  $\text{Ca} + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2$
- C  $\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2$
- D  $\text{CaCO}_3 + 2\text{NaCl} \rightarrow \text{CaCl}_2 + \text{Na}_2\text{CO}_3$

(Total for Question 4 = 1 mark)

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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  $1s^2 2s^2 2p^6 3s^2$
- B  $1s^2 2s^2 2p^6 3s^2 3p^6$
- C  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$
- D  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$

(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  $\text{SF}_6(\text{g})$
- B  $\text{H}_2\text{O}(\text{l})$
- C  $\text{Hg}(\text{l})$
- D  $\text{Na}_2\text{O}(\text{s})$

(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  $\text{N}^{3-}$
- B  $\text{F}^-$
- C  $\text{Na}^+$
- D  $\text{Al}^{3+}$

(Total for Question 9 = 1 mark)

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

- A  $\text{S}^{2-}$
- B  $\text{Cl}^-$
- C  $\text{K}^+$
- D  $\text{Ca}^{2+}$

(Total for Question 10 = 1 mark)

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

- A  $\text{C}_{60}$  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  $\text{OF}_2$
- C  $\text{BF}_3$
- D  $\text{CF}_4$

(Total for Question 12 = 1 mark)

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13 A substance is labelled with the hazard symbol shown.

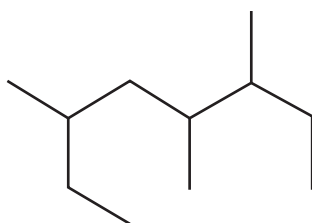


What is the meaning of this symbol?

- 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

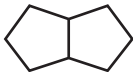

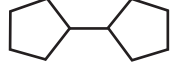

(c) Which free radical is **least** likely to form in a propagation step in this reaction system?

(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)

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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)

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**TOTAL FOR SECTION A = 20 MARKS**



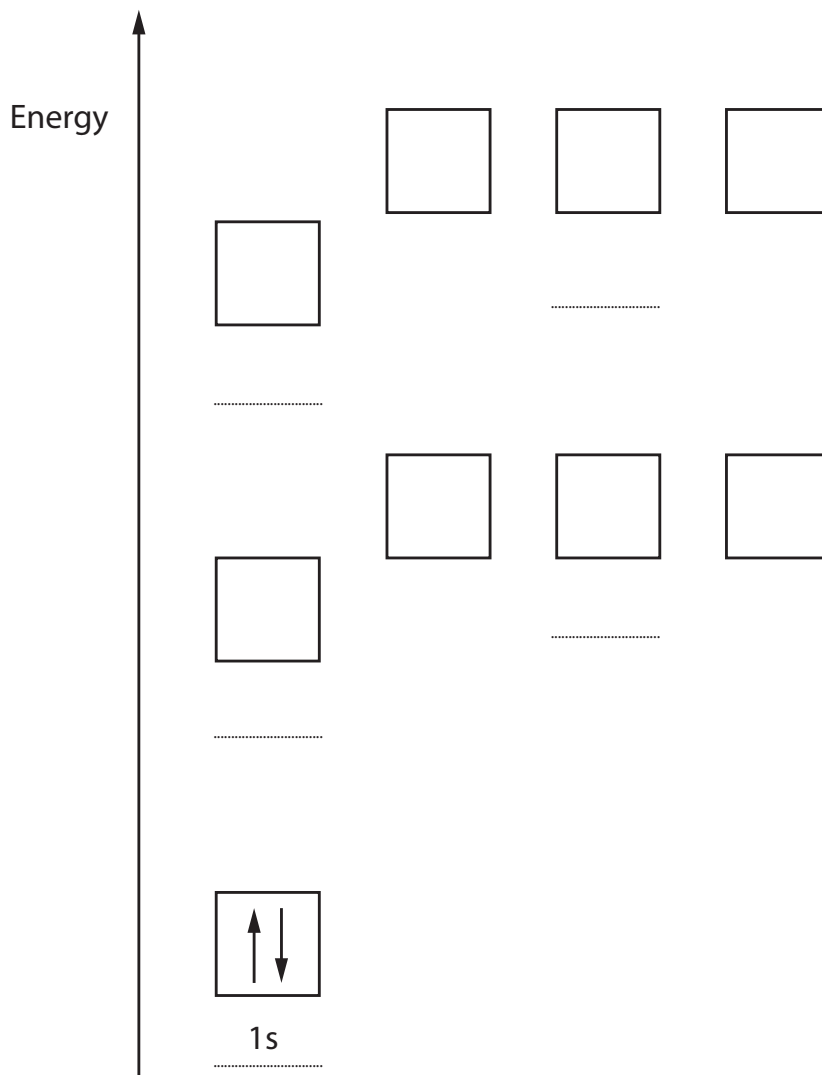
## SECTION B

**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)



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

(2)





(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	$^{32}\text{S}$	$^{33}\text{S}$	$^{34}\text{S}$	$^{36}\text{S}$
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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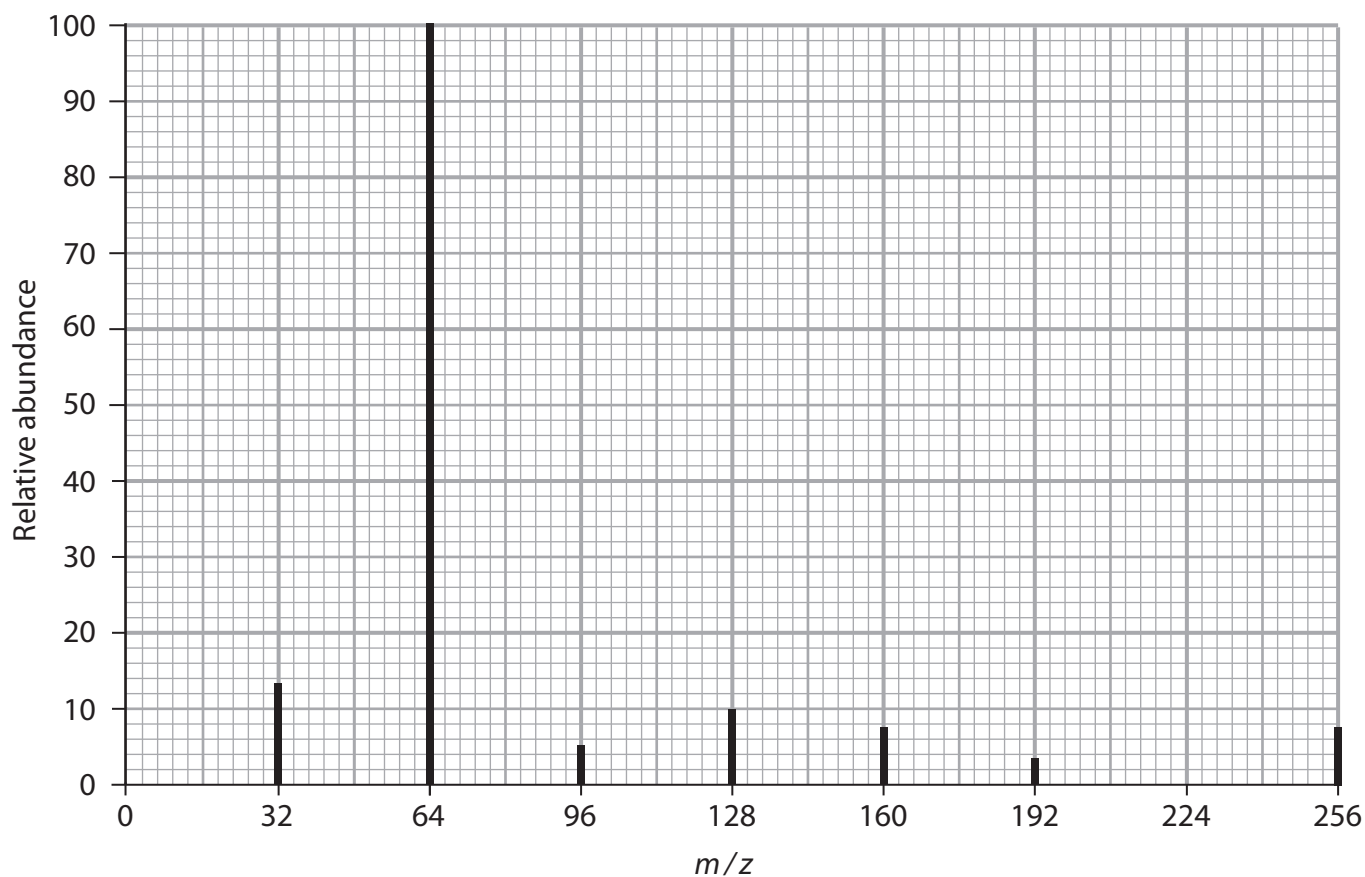
(ii) Calculate the relative atomic mass of sulfur in this sample.

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

(2)



(e) The mass spectrum of a sample of sulfur with  $^{32}\text{S}$  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)

(Total for Question 18 = 14 marks)



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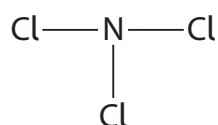
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19 This question is about the structure and bonding of Group 5 chlorides.

(a) Nitrogen trichloride,  $\text{NCl}_3$ , has a molecular structure.

The displayed formula of a molecule of  $\text{NCl}_3$  is shown.



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 ( $\text{PCl}_5$ ) is a solid made up of  $\text{PCl}_4^+$  cations and  $\text{PCl}_6^-$  anions.

Antimony(V) chloride ( $\text{SbCl}_5$ ) is a liquid made up of  $\text{SbCl}_5$  molecules.

(i) Explain why  $\text{PCl}_5$  has a higher melting temperature than  $\text{SbCl}_5$ .

(2)

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(ii) Draw a dot-and-cross diagram to show the bonding in a molecule of  $\text{SbCl}_5$ .

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

(2)

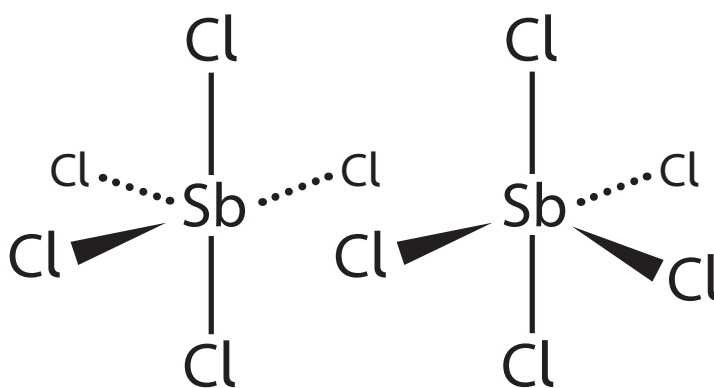
(c) At low temperatures,  $\text{SbCl}_5$  converts to  $\text{Sb}_2\text{Cl}_{10}$  which contains dative covalent bonds.

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

(1)

(ii) Complete the diagram to show the dative covalent bonds in  $\text{Sb}_2\text{Cl}_{10}$ .

(1)



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(d) Arsenic also forms a pentachloride with the formula  $\text{AsCl}_5$ .

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

(1)

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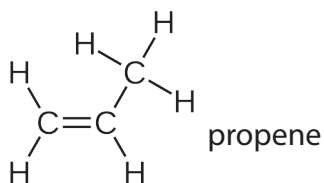
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**(Total for Question 19 = 10 marks)**



20 This question is about the reactions of 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)



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

(3)

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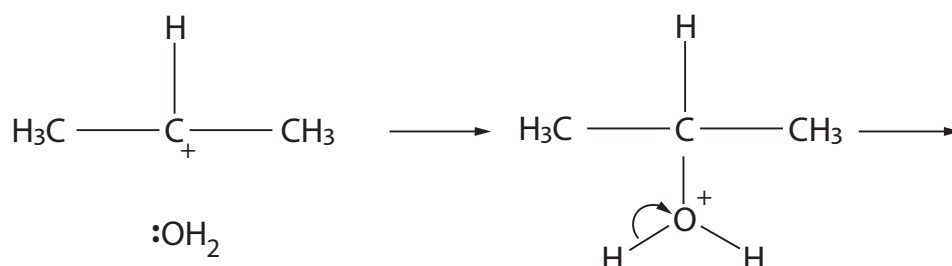
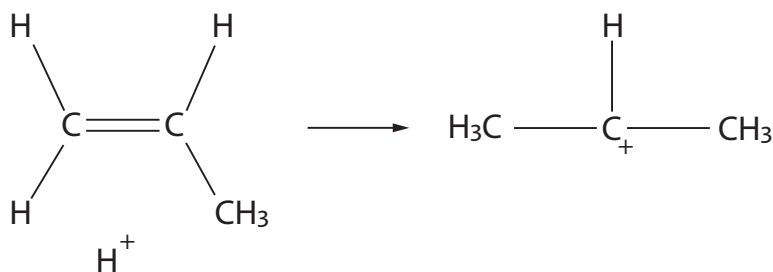


- (e) Propene reacts with steam in the presence of an acid catalyst to form a mixture of the alcohols propan-1-ol and propan-2-ol.

Complete the mechanism for the formation of propan-2-ol, by adding curly arrows.

Include the species formed in the final step.

(3)

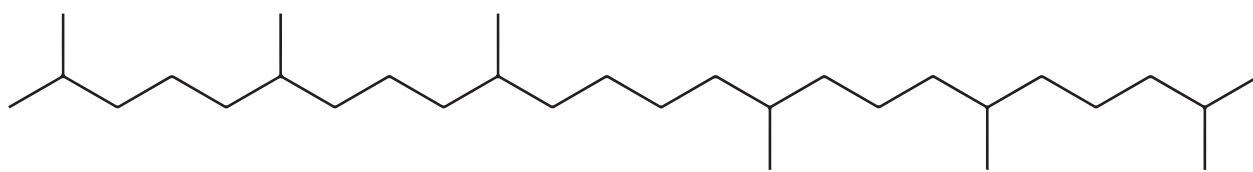


(Total for Question 20 = 12 marks)





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)

(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)

(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  $4.0 \times 10^5$  Pa.

Under these conditions, the complete hydrogenation of squalene requires 500 m<sup>3</sup> of hydrogen gas.

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

You **must** show your working.

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

(4)

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

(1)

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- (d) Globally, 2.8 million  $\text{dm}^3$  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)

- (ii) Calculate the minimum number of sharks that would be needed to produce 2.8 million  $\text{dm}^3$  of squalene.

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

(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.

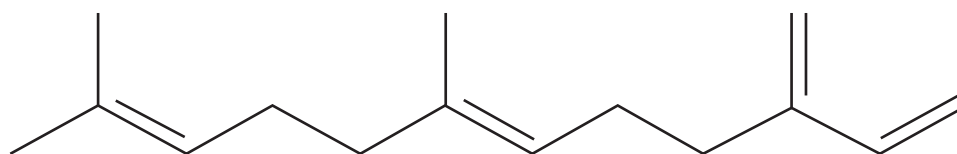
Calculate the area of land, **in  $\text{km}^2$** , required to produce 2500 tonnes of squalane from corn starch.

[1 tonne = 1000 kg                      1 hectare =  $0.01 \text{ km}^2$ ]

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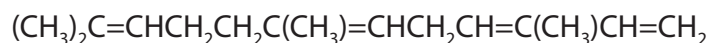
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(f) The compound alpha-farnesene,  $C_{15}H_{24}$ , is a structural isomer of beta-farnesene.

The structural formula of alpha-farnesene is



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

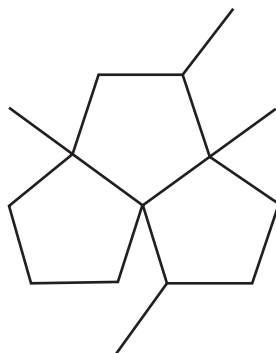
(2)

(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



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# The Periodic Table of Elements

1 2 3 4 5 6 7 0 (8) (18)

1.0	<b>H</b>	hydrogen	1
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### Key

relative atomic mass
<b>atomic symbol</b>
name
atomic (proton) number

(1) (2)

6.9	<b>Li</b>	lithium	3
9.0	<b>Be</b>	beryllium	4
23.0	<b>Na</b>	sodium	11
24.3	<b>Mg</b>	magnesium	12

(13)

10.8	<b>B</b>	boron	5
12.0	<b>C</b>	carbon	6
27.0	<b>Al</b>	aluminium	13
28.1	<b>Si</b>	silicon	14

(14)

14.0	<b>N</b>	nitrogen	7
16.0	<b>O</b>	oxygen	8
31.0	<b>P</b>	phosphorus	15
32.1	<b>S</b>	sulfur	16

(15)

14.0	<b>N</b>	nitrogen	7
16.0	<b>O</b>	oxygen	8
31.0	<b>P</b>	phosphorus	15
32.1	<b>S</b>	sulfur	16

(16)

19.0	<b>F</b>	fluorine	9
35.5	<b>Cl</b>	chlorine	17

(17)

19.0	<b>F</b>	fluorine	9
35.5	<b>Cl</b>	chlorine	17

(18)

4.0	<b>He</b>	helium	2
20.2	<b>Ne</b>	neon	10
39.9	<b>Ar</b>	argon	18

(3) (4) (5) (6) (7) (8) (9) (10) (11) (12)

45.0	<b>Sc</b>	scandium	21
47.9	<b>Ti</b>	titanium	22
50.9	<b>V</b>	vanadium	23
52.0	<b>Cr</b>	chromium	24
54.9	<b>Mn</b>	manganese	25
55.8	<b>Fe</b>	iron	26
58.9	<b>Co</b>	cobalt	27
58.7	<b>Ni</b>	nickel	28
63.5	<b>Cu</b>	copper	29
65.4	<b>Zn</b>	zinc	30
69.7	<b>Ga</b>	gallium	31
72.6	<b>Ge</b>	germanium	32
74.9	<b>As</b>	arsenic	33
79.0	<b>Se</b>	selenium	34
79.9	<b>Br</b>	bromine	35
83.8	<b>Kr</b>	krypton	36
85.5	<b>Rb</b>	rubidium	37
87.6	<b>Sr</b>	strontium	38
88.9	<b>Y</b>	yttrium	39
91.2	<b>Zr</b>	zirconium	40
92.9	<b>Nb</b>	niobium	41
95.9	<b>Mo</b>	molybdenum	42
98	<b>Tc</b>	technetium	43
101.1	<b>Ru</b>	ruthenium	44
102.9	<b>Rh</b>	rhodium	45
106.4	<b>Pd</b>	palladium	46
107.9	<b>Ag</b>	silver	47
112.4	<b>Cd</b>	cadmium	48
114.8	<b>In</b>	indium	49
118.7	<b>Sn</b>	tin	50
121.8	<b>Sb</b>	antimony	51
126.9	<b>I</b>	iodine	53
127.6	<b>Te</b>	tellurium	52
131.3	<b>Xe</b>	xenon	54
137.3	<b>Ba</b>	barium	56
138.9	<b>La*</b>	lanthanum	57
178.5	<b>Hf</b>	hafnium	72
180.9	<b>Ta</b>	tantalum	73
186.2	<b>Re</b>	rhenium	75
190.2	<b>Os</b>	osmium	76
192.2	<b>Ir</b>	iridium	77
195.1	<b>Pt</b>	platinum	78
197.0	<b>Au</b>	gold	79
200.6	<b>Hg</b>	mercury	80
204.4	<b>Tl</b>	thallium	81
207.2	<b>Pb</b>	lead	82
209.0	<b>Bi</b>	bismuth	83
209	<b>Po</b>	polonium	84
210	<b>At</b>	astatine	85
222	<b>Rn</b>	radon	86
227	<b>Fr</b>	francium	87
226	<b>Ra</b>	radium	88
227	<b>Ac*</b>	actinium	89
261	<b>Rf</b>	rutherfordium	104
262	<b>Db</b>	dubnium	105
266	<b>Sg</b>	seaborgium	106
264	<b>Bh</b>	bohrium	107
277	<b>Hs</b>	hassium	108
271	<b>Ds</b>	darmstadtium	110
272	<b>Rg</b>	roentgenium	111

Elements with atomic numbers 112-116 have been reported but not fully authenticated

\* Lanthanide series  
\* Actinide series

140	<b>Ce</b>	cerium	58
141	<b>Pr</b>	praseodymium	59
144	<b>Nd</b>	neodymium	60
147	<b>Pm</b>	promethium	61
150	<b>Sm</b>	samarium	62
152	<b>Eu</b>	europium	63
157	<b>Gd</b>	gadolinium	64
159	<b>Tb</b>	terbium	65
163	<b>Dy</b>	dysprosium	66
165	<b>Ho</b>	holmium	67
167	<b>Er</b>	erbium	68
169	<b>Tm</b>	thulium	69
173	<b>Yb</b>	ytterbium	70
175	<b>Lu</b>	lutetium	71
232	<b>Th</b>	thorium	90
231	<b>Pa</b>	protactinium	91
238	<b>U</b>	uranium	92
237	<b>Np</b>	neptunium	93
242	<b>Pu</b>	plutonium	94
243	<b>Am</b>	americium	95
247	<b>Cm</b>	curium	96
245	<b>Bk</b>	berkelium	97
251	<b>Cf</b>	californium	98
254	<b>Es</b>	einsteinium	99
253	<b>Fm</b>	fermium	100
256	<b>Md</b>	mendeleevium	101
254	<b>No</b>	nobelium	102
257	<b>Lr</b>	lawrencium	103

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