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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 ▶

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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_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)

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5 Which of these atoms has the most neutrons?

- ☒ **A** $^{115}_{49}In$
- ☒ **B** $^{124}_{50}Sn$
- ☒ **C** $^{123}_{51}Sb$
- ☒ **D** $^{124}_{52}Te$

(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** $SF_6(g)$
- ☒ **B** $H_2O(l)$
- ☒ **C** $Hg(l)$
- ☒ **D** $Na_2O(s)$

(Total for Question 8 = 1 mark)

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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)

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13 A substance is labelled with the hazard symbol shown.

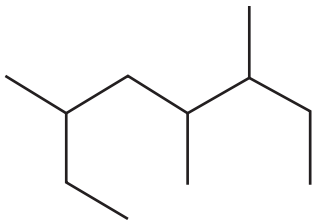


What is the meaning of this symbol?

- ☒ **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)

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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

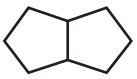
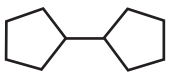
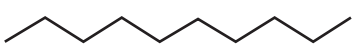
(c) Which free radical is **least** likely to form in a propagation step in this reaction system?

(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)

TOTAL FOR SECTION A = 20 MARKS

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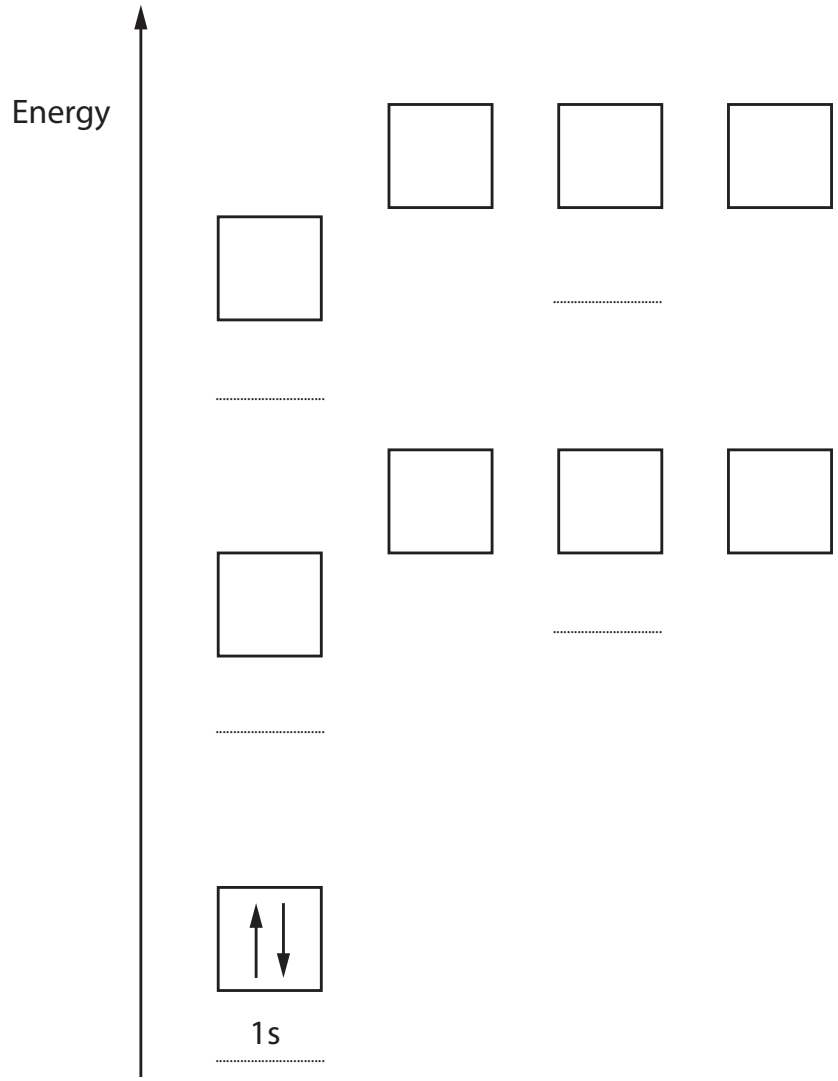
SECTION B

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)

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

(3)

(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)

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

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

(2)

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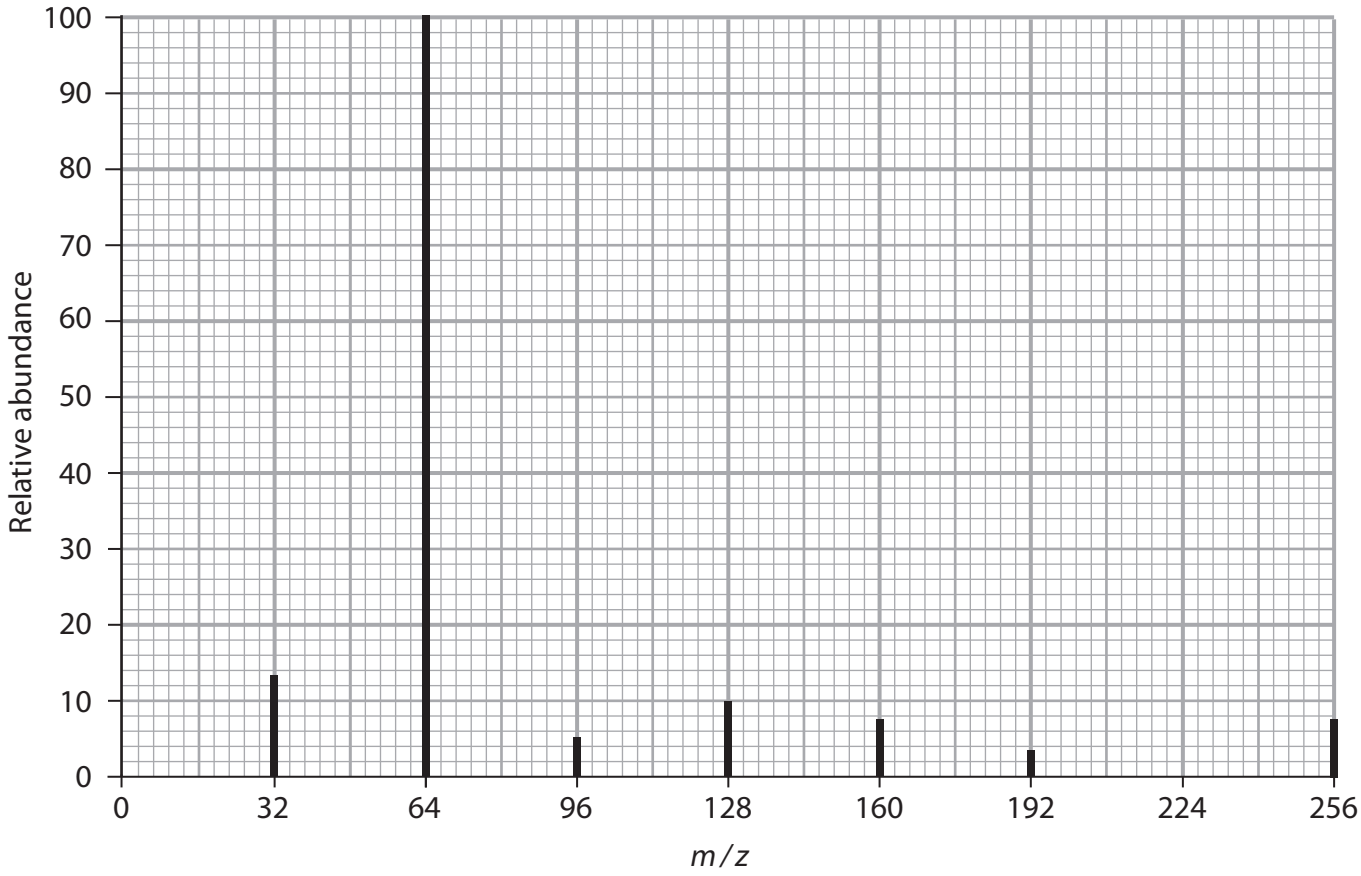
(e) The mass spectrum of a sample of sulfur with ^{32}S as the only isotope is shown.



(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)

(Total for Question 18 = 14 marks)

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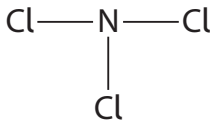
19 This question is about the structure and bonding of Group 5 chlorides.

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

The displayed formula of a molecule of NCl_3 is shown.



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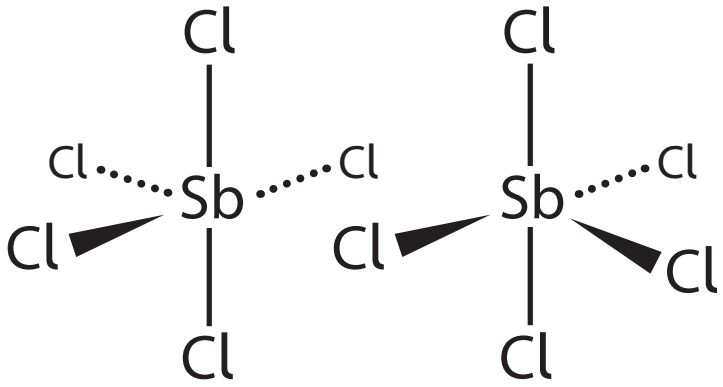
(ii) Complete the diagram to show the dative covalent bonds in Sb_2Cl_{10}.

(1)



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(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)

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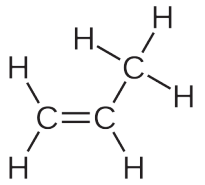
20 This question is about the reactions of propene.



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)

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(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)

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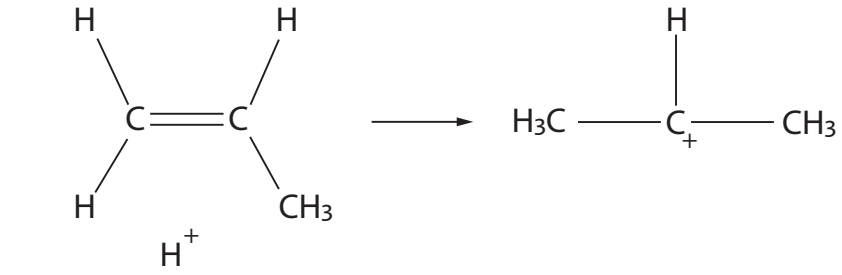
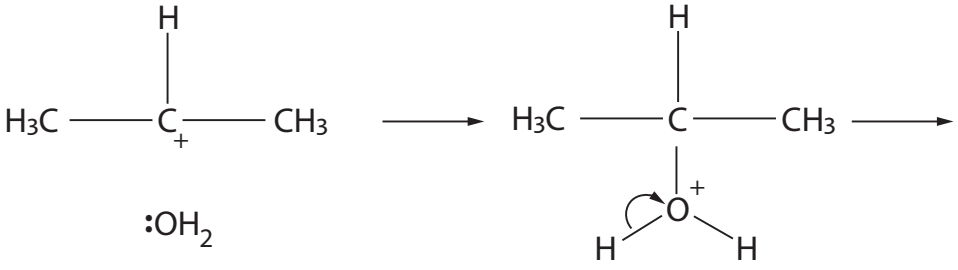
(e) Propene reacts with steam in the presence of an acid catalyst to form a mixture of the alcohols propan-1-ol and propan-2-ol.

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

(3)





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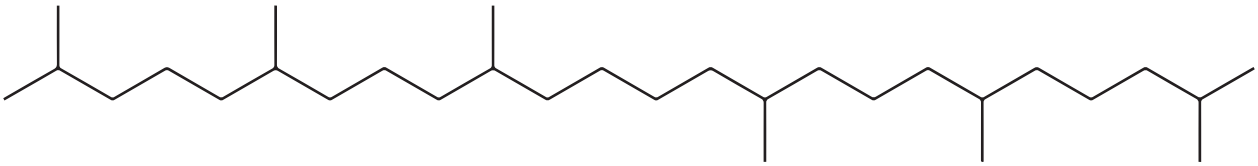
21 This question is about the production of squalane, a liquid alkane which occurs naturally in human skin and is used in cosmetics.



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)

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(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)

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(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)

.....

(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 km^2**, required to produce 2500 tonnes of squalane from corn starch.

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

(3)

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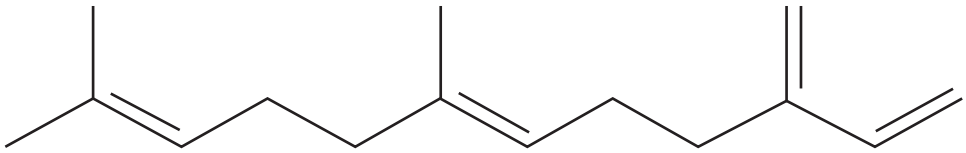
(e) The *E*-isomer of beta-farnesene can also be obtained from corn starch.



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)

(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)

.....

.....

.....

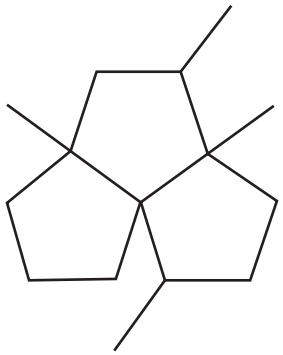
(ii) State the number of **geometric** isomers of alpha-farnesene.

(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 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

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

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

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