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A' Level Chemistry

Year 1

Unit 4: Introduction to Organic Chemistry & Alkanes

Summer Examination Revision Pack

The questions in this pack should be attempted **AFTER** completing all other revision.

Grade Accelerator

Recall Definitions
Drawing Diagrams
Using Equations
Drawing Graphs

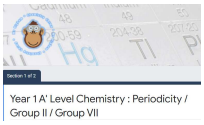
Quizlet

Quizlet Classes

Flashcard Based
Games
Tests & Quizzes
Keyword Spell Checker

Condensed Notes

Keywords & Definitions
Key Concepts
Application
Key Skills



Online Forms

Take Time to Answer
Use Paper & Calculator
Work It Out
Review Missed Marks

Use the 3 Wave Process when completing these revision packs.

1. Complete the questions without assistance
(Can't answer a question? Leave it and move on)
2. Use your notes to fill any gaps after step 1
3. Use the mark scheme to fill in any remaining gaps.

1. Having gaps after step 1 is normal, that's why we are doing revision!
2. If your notes don't help during step 2, they are not good enough!
(Change your note taking method and try to understand the problem)
3. If you don't understand why the mark scheme answer is correct, **see Andy.**

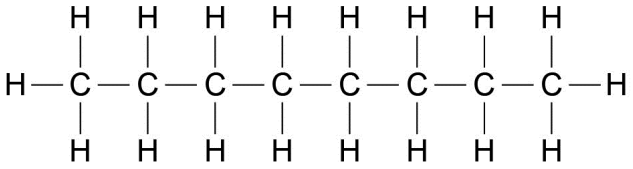
If you struggle with the questions in the pack, **STOP!** and complete some more revision.

If you come to a complete dead-end, **STOP!** and speak to **Andy** asap.

3 Octane and isooctane are structural isomers with the molecular formula C_8H_{18}
The displayed formulas and boiling points of octane and isooctane are shown in **Figure 2**.

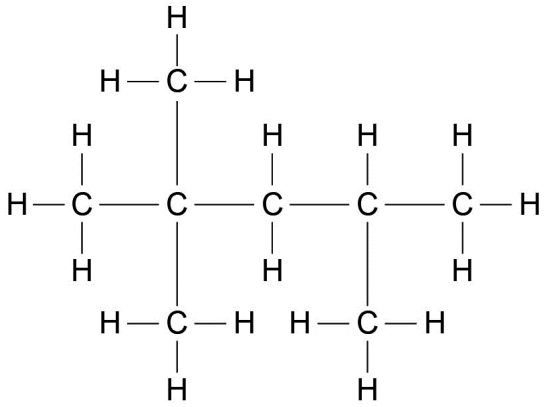
Figure 2

Octane



Boiling point: 125 °C

Isooctane



Boiling point: 99 °C

0 3 . 1 Give the IUPAC name for isooctane.

[1 mark]

0 3 . 2 Octane and isooctane can be separated in the laboratory.

Name a laboratory technique that could be used to separate isooctane from a mixture of octane and isooctane.

Outline how this technique separates isooctane from octane.

[3 marks]

Name _____

Outline _____

0 3 . 3 Isooctane is added to petrol to increase its octane rating. Some high-performance engines require fuel with a higher octane rating.

Write an equation for the complete combustion of isooctane. Use the molecular formula (C_8H_{18}) of isooctane in your equation.

[1 mark]

0 3 . 4 Explain, in general terms, how a catalyst works.

[2 marks]

0 3 . 5 Carbon monoxide is produced when incomplete combustion takes place in engines. Nitrogen monoxide is another pollutant produced in car engines.

Write an equation to show how these pollutants react together in a catalytic converter.

[1 mark]

0 3 . 6 Platinum, palladium and rhodium are metals used inside catalytic converters. A very thin layer of the metals is used on a honeycomb ceramic support.

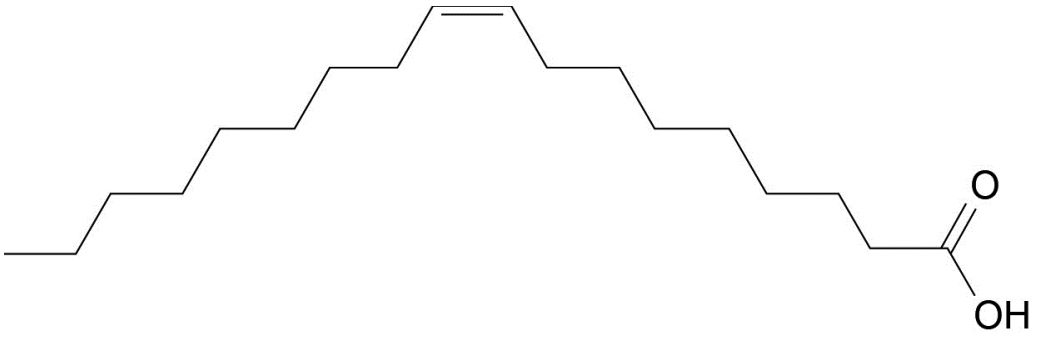
Explain why a thin layer is used in this way.

[2 marks]

Question 3 continues on the next page

0 3 . 7 Oleic acid ($C_{18}H_{34}O_2$) is a straight-chain fatty acid obtained from plant oils. Isooctane can be made from oleic acid. The skeletal formula of oleic acid is shown in **Figure 3**.

Figure 3



Identify a reagent that could be used in a chemical test to show that oleic acid is unsaturated.

State what would be observed in this test.

[2 marks]

Reagent _____

Observation _____

_____

Question	Marking Guidance	Mark	Comments
03.1	2,2,4-trimethylpentane	1	This answer only but ignore punctuation
03.2	M1 (fractional or simple) distillation M2 idea that isooctane / the one with the lower boiling point boils (first) (or reaches top of column first) M3 idea that isooctane <u>condenses / liquefies</u> and <u>collected</u> (where collected = idea that it is separated / collected (away from the octane))	1 1 1	Incorrect process in M1 CE=0 If M1 blank, mark on for M2 and M3 (ignore boiling, condensing) Ignore reference to octane boiling and being collected at higher temperature If temperature referred to, should be between 99 and 124°C "it" refers to isooctane M2 – allow vaporises/evaporates first Penalise M2 and M3 if octane boils first In M2 and M3 – if no specific reference to individual alkanes, could score one mark for M2 + M3 combined if M2 and M3 both otherwise correct M2 and M3 must refer laboratory apparatus (not to an industrial process)
03.3	$C_8H_{18} + 12½O_2 \rightarrow 8CO_2 + 9H_2O$	1	Accept multiples; ignore state symbols Accept any correct structural representation of isooctane

03.4	M1 Alternative route/mechanism/pathway M2 With lower <u>activation energy</u>	1 1	 Accept E_a for activation energy

03.5	$2CO + 2NO \rightarrow 2CO_2 + N_2$	1	Accept multiples; ignore state symbols

03.6	M1 to reduce amount of metals needed / small amount of metal needed M2 Increase / maximise / produce large surface area or to give catalyst a larger surface area: volume ratio or so that high(er) proportion of atoms/metal is on surface	1 1	M1 relates to low amount of metal M2 is related to large surface area

03.7	M1 bromine (water or in organic solvent or CCl_4) / Br_2 (aq) / Br_2 M2 (orange/yellow to) colourless / decolourised / loses its colour	1 1	M1 no reagent or an incorrect reagent (e.g. bromide), CE=0; penalise Br (or incorrect formula of other correct reagent) but mark on for M2 it must be a whole reagent and/or correct formula If oxidation state given in name, it must be correct. If 'manganate' or 'manganate(IV)' or incorrect formula, penalise M1 but mark on. ignore 'acidified' M2 ignore goes clear ignore brown/red, but penalise other incorrect colours *Alternatives:* M1 = potassium manganate(VII), M2 = colourless M1 = <u>conc</u> sulfuric acid, M2 = brown M1 = iodine, M2 = colourless

0 3 . 1 Compounds **A**, **B** and **C** all have the molecular formula C_5H_{10}

A and **B** decolourise bromine water but **C** does not.

B exists as two stereoisomers but **A** does **not** show stereoisomerism.

Use this information to deduce a possible structure for each of compounds **A, B** and **C** and explain your deductions.

State the meaning of the term stereoisomers and explain how they arise in compound **B**.

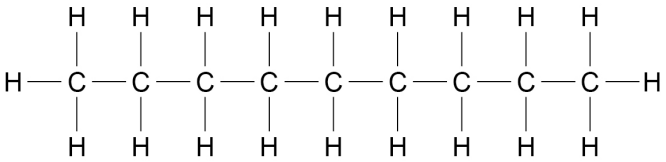
[6 marks]

6

Ques	Marking Guidance		Mark	Comments
03	This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.		6	Indicative chemistry content **Stage 1 – deduces which compounds are saturated/unsaturated** 1a states that A & B are unsaturated / do contain C=C / alkenes (this can be obtained from the structures) 1b as they decolourise bromine water 1c states that C is saturated / does not contain C=C / is (cyclo)alkane (this can be obtained from the structures) 1d as it does not decolourise bromine water **Stage 2 – deduces the structures** 2a suggests suitable name/structure for **A** • pent-1-ene, • 2-methylbut-1-ene, • 3-methylbut-1-ene, • 2-methylbut-2-ene 2b **B** = pent-2-ene (name/structure) 2c suggests a suitable name/structure of **C** (cyclopentane, methylcyclobutane, any dimethylcyclopropane) **Stage 3 – can explain the stereoisomerism** 3a explains what stereoisomerism is in terms of molecules with the same structural formula but a different arrangement of atoms/bonds/groups in space 3b explains how it arises by discussing that C=C cannot rotate, 3c explains how it arises by discussing that each C in C=C has two different groups (ignore reference to M_r in this context) <u>or</u> by drawing the E and Z isomers of **B** Note • compounds may be identified by name or structure (but if both given and there is error in one, then award lower mark in whichever level the answer fits, i.e. it penalises the mark within a level, but not the overall level itself)
	Level 3 (5-6 marks)	All stages are covered, three correct structures are given and each stage is generally correct and virtually complete. Answer communicates reasoning coherently and shows a logical progression through the identification of structures including explaining about stereoisomerism.		
	Level 2 (3-4 marks)	Two stages are covered or parts of three stages (if two stages are covered, they must be complete for 4 marks)		
	Level 1 (1-2 marks)	One stage covered or parts of two stages (if one stage is covered, it must be complete for 2 marks)		
	Level 0 (0 marks)	No relevant correct chemistry to warrant a mark.		

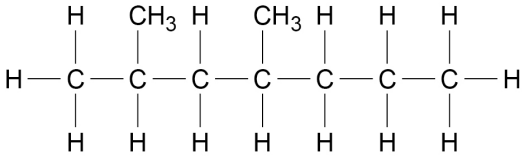
0 4 The alkanes nonane and 2,4-dimethylheptane are structural isomers with the molecular formula C_9H_{20}
They are found in crude oil and can be separated by fractional distillation.
Both can be used in fuels or cracked to form other products.

nonane



boiling point 151 °C

2,4-dimethylheptane



boiling point 134 °C

0 4 . 1 State the general formula of an alkane containing *n* carbon atoms.
Deduce an expression for the relative molecular mass (M_r) of an alkane in terms of *n*.
[2 marks]

General formula _____

Expression _____

0 4 . 2 Explain why nonane has a higher boiling point than 2,4-dimethylheptane.
[2 marks]

_____

_____

_____

_____

_____

_____

0 4 . 3 Give an equation for the complete combustion of nonane.

[1 mark]

0 4 . 4 Nonane is often found in fuel for jet engines. Combustion in jet engines produces pollutants including nitrogen monoxide (NO).

Explain how this nitrogen monoxide is formed.

[2 marks]

0 4 . 5 Nonane can be cracked to form large quantities of propene.

Name the type of cracking used.

[1 mark]

0 4 . 6 The main use of propene, formed from cracking, is to make poly(propene).

Draw the repeating unit of poly(propene).

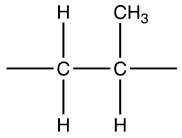
[1 mark]

9

Turn over for the next question

Question	Marking Guidance	Mark	Comments
4.1	**M1** C_nH_{2n+2} **M2** 14.0*n* + 2.0 or 14n + 2	1 1	 or 2(7.0n + 1.0) or 2.0(7n + 1) or 2(7n + 1)
4.2	**M1** nonane has stronger / greater / more <u>van der Waals' forces between molecules</u> **M2** nonane molecules pack closer together / more (surface) contact	1 1	or converse arguments for 2,4-dimethylbutane having lower boiling point question refers to nonane if not expressly stated by candidate intermolecular forces = forces between molecules **M1** ignore abbreviations vdW and/or imf **M2** ignore reference to surface area alone CE=0 reference to breaking (covalent) bonds / breaking chain
4.3	$C_9H_{20} + 14O_2 \rightarrow 9CO_2 + 10H_2O$	1	allow multiples; ignore any state symbols; correct structures rather than formulae are fine
4.4	**M1** nitrogen and oxygen from air react **M2** at high temperature	1 1	**M1** must be at least one reference to air and no reference to nitrogen/oxygen coming from the fuel ignore reference to pressure, heat, hot, incomplete combustion if temperature is stated, must be over 1000°C

4.5	thermal (cracking)	1	

4.6		1	allow any correct structural representation ignore any n or brackets

Do not write outside the box

0 4 This question is about fossil fuels.

0 4 . 1 The petrol fraction from crude oil contains octane (C_8H_{18}).

Give an equation for the complete combustion of octane.

[1 mark]

0 4 . 2 The combustion of petrol in car engines produces the pollutant nitrogen monoxide.

Give an equation for a reaction that removes nitrogen monoxide in a catalytic converter.

[1 mark]

Question 4 continues on the next page

Question	Marking guidance	Additional Comments/Guidelines	Mark
04.1	$C_8H_{18} + 12.5O_2 \rightarrow 8CO_2 + 9H_2O$	Allow multiples Ignore state symbols	1
04.2	$2NO + 2CO \rightarrow N_2 + 2CO_2$ ***or*** $25NO + C_8H_{18} \rightarrow 12.5N_2 + 9H_2O + 8CO_2$	Allow multiples Ignore state symbols Allow $2NO \rightarrow N_2 + O_2$ (or multiples)	1

Do not write outside the box

0 1 . 3 1-chloropropane can also be produced by the reaction between propane and chlorine in the presence of ultraviolet light.

State why ultraviolet light is needed for this reaction to occur.

Give an equation for each propagation step in the formation of 1-chloropropane from propane.

[3 marks]

Why ultraviolet light is needed

Propagation step 1

Propagation step 2

0 1 . 4 The C–Cl bond in 1-chloropropane is polar because carbon and chlorine have different electronegativities.

Define the term electronegativity.

[1 mark]

Question 1 continues on the next page

Do not write outside the box

0 1 . 5 Ammonia reacts with 1-chloropropane to form propylamine.

Name and outline the mechanism for this reaction.

[5 marks]

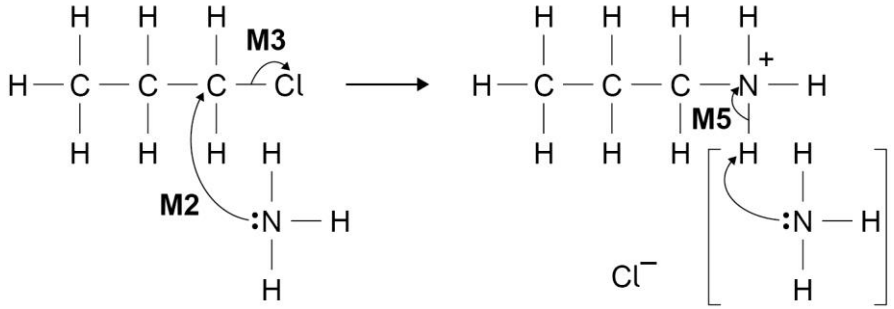
Name of mechanism _____

Outline of mechanism

14

01.3	**M1** provides energy to break (covalent) bond in chlorine / Cl_2 or to form chlorine free radicals **M2** $CH_3CH_2CH_3 + {\bullet}Cl \rightarrow {\bullet}CH_2CH_2CH_3 + HCl$ **M3** ${\bullet}CH_2CH_2CH_3 + Cl_2 \rightarrow ClCH_2CH_2CH_3 + {\bullet}Cl$	**M2** and **M3**: • must show structure of ${\bullet}CH_2CH_2CH_3$ in at least one of the equations to score both marks (dot must be on or around the end CH_2 group), but only penalise ${\bullet}C_3H_7$ once across both equations if both equations otherwise correct • on this occasion, molecular formula of propane can be allowed for **M2** • on this occasion, molecular formula of 1-chloropropane can be allowed for **M3** • penalise absence of radical dots once • allow equations in either order	1 1 1

01.4	the ability/power of atom to attract/withdraw the <u>2/pair</u> of electrons in a covalent bond	allow nucleus in place of atom	1

01.5	**M1** nucleophilic substitution **M4 Structure**  **M2** curly arrow from lone pair on N of NH_3 to the correct C atom **M3** must show the movement of a pair of electrons from the C−Cl bond to the Cl atom; mark **M3** independently provided it is from <u>their original molecule</u> **M4** is for the structure of the alkylammonium ion, which could be a condensed formula; a positive charge must be shown on, or close to, the N atom **M5** is for an arrow from the N−H bond to the N atom	For the mechanism Penalise **M2** if negative charge on ammonia Penalise **M3** for formal charge on C and/or Cl of C–Cl or incorrect partial charges on C–Cl; ignore other partial charges on uncharged atoms penalise **M3** for any additional arrow(s) to/from the Cl to/from anything else the second molecule of NH_3 is not essential for **M5**, but penalise **M5** if used incorrectly (but only penalise once in **M2** and **M5** for negative charge on ammonia) <u>SN1 mechanism alternative</u> (loss of Cl first followed by attack by NH_3) : **M2** curly arrow from C–Cl bond to the Cl **M3** curly arrow from lone pair of NH_3 to correct C on the correct carbocation	1 1 1 1

Do not write outside the box

0 5 Explain the differences between structural isomerism and stereoisomerism.
Use examples to show how compounds with the molecular formula C_4H_8 exhibit stereoisomerism and the three types of structural isomerism.

[6 marks]

Do not write outside the box

6

Turn over ►

<table>
<tr><th>Question</th><th>Marking guidance</th><th>Additional Comments/Guidelines</th><th>Mark</th></tr>
<tr>
<td>05</td>
<td>
This question is marked using levels of response.
Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.
<table>
<tr><td>Level 3
(5-6 marks)</td><td>All stages are covered and each stage is generally correct and virtually complete.

(6 v 5) Answer is well structured, with no repetition or irrelevant points, and covers all aspects of the question. Accurate and clear expression of ideas with no errors in use of technical terms.</td></tr>
<tr><td>Level 2
(3-4 marks)</td><td>All stages are covered but stage(s) may be incomplete or may contain inaccuracies OR

two stages are covered and are generally correct and virtually complete

(4 v 3) Answer has some structure and covers most aspects of the question. Ideas are expressed with reasonable clarity with, perhaps, some repetition or some irrelevant points. If any, only minor errors in use of technical terms.</td></tr>
<tr><td>Level 1
(1-2 marks)</td><td>Two stages are covered but stage(s) may be incomplete or may contain inaccuracies OR

only one stage is covered but is generally correct and virtually complete

(2 v 1) Answer includes statements which are presented in a logical order and/or linked.</td></tr>
<tr><td>0 marks</td><td>Insufficient correct chemistry to warrant a mark.</td></tr>
</table>
</td>
<td>
Indicative chemistry

Stage 1
Difference between structural & stereoisomers
1a structural isomers = molecules with same molecular formula but different structure
1b stereoisomers = molecules with same structural formula but different arrangement of atoms in space

Stage 2
Stereoisomers
2a lack of rotation around C=C
2b structures of E- and Z-but-2-ene
2c correct identity of E and Z isomers

Stage 3
Structural isomers
3a different C chain, e.g. methylpropene & but-1-ene / but-2-ene
3b different position of functional group e.g. but-1-ene & but-2-ene
3c different functional group, e.g. cyclobutane & but-1-ene / but-2-ene / methylpropene
</td>
<td>6</td>
</tr>
</table>

Do not write outside the box

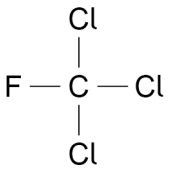
0 4 CFCs were used as refrigerants and in aerosols.

The scientists Rowland and Molina published research in 1974 to show that CFCs are responsible for the destruction of ozone molecules in the upper atmosphere.

A few years later, other scientists discovered that the concentration of ozone in the upper atmosphere was decreasing.

In 1987 there was an agreement by many countries to restrict the use of CFCs.

0 4 . 1 The molecule CFC-11 was commonly used as a refrigerant.



Use IUPAC rules to name CFC-11

[1 mark]

0 4 . 2 A molecule of CFC-11 breaks down in the upper atmosphere to form a chlorine free radical.

Give the equation for this reaction.

[1 mark]

Do not write outside the box

0 4 . 3 A typical refrigerator contained 0.50 kg of CFC-11 (M_r = 137.5).

One molecule of CFC-11 causes the destruction of approximately 100 000 molecules of ozone.

Use these data to estimate the number of molecules of ozone that can be destroyed by 0.50 kg of CFC-11
Give your answer in standard form.

The Avogadro constant, $L = 6.022 \times 10^{23}$ mol^{-1}

[2 marks]

Number of molecules of ozone _____

0 4 . 4 State the benefit to life on Earth of ozone in the upper atmosphere.

[1 mark]

_____

_____

_____

0 4 . 5 Suggest **one** reason why the use of CFCs was not restricted until several years after Rowland and Molina published their research.

[1 mark]

_____

_____

_____

Turn over ►

Do not write outside the box

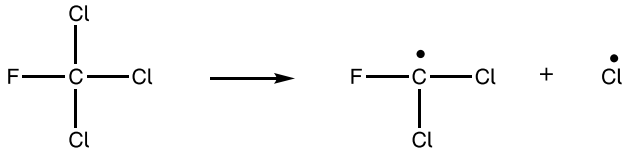
0 4 . 6 CFC-11 is a greenhouse gas that can contribute to global warming.

State and explain how CFC-11 is able to contribute to global warming.

[2 marks]

8

Question	Marking guidance	Additional Comments/Guidelines	Mark
04.1	trichlorofluoromethane		1

Question	Marking guidance	Additional Comments/Guidelines	Mark
04.2		$CCl_3F \rightarrow \bullet CCl_2F + \bullet Cl$ radical dot anywhere on each radical	1

Question	Marking guidance	Additional Comments/Guidelines	Mark
04.3	**M1** amount of CFC-11 = $\frac{500}{137.5}$ (= 3.64) mol **M2** molecules of O_3 = 3.64 x 100,000 x 6.022 x 10^{23} = 2.19 x 10^{29}	Allow ECF from **M1** to **M2** Allow answers in range 2 x 10^{29} to 2.20 x 10^{29} (1sf is acceptable as this is an estimate)	1 1

Question	Marking guidance	Additional Comments/Guidelines	Mark
04.4	Absorbs (harmful) ultraviolet / uv (light / radiation)	Protects us from (harmful) uv Ignore other wavelengths / types of light	1

Question	Marking guidance	Additional Comments/Guidelines	Mark
04.5	One of these reasons: • lack of evidence that ozone was being depleted • lack of alternatives to CFCs • commercial interest to continue to use CFCs • hard to obtain international agreement		1

Question	Marking guidance	Additional Comments/Guidelines	Mark
04.6	**M1** absorbs infrared radiation **M2** molecule has polar bonds	**M1** idea of IR being taken in **M2** accept polar molecule	1 1

Do not write outside the box

0 5 This question is about poly(propene).

0 5 . 1 The three key steps in the manufacture of poly(propene) from crude oil are shown.

crude oil —step **1**→ naphtha —step **2**→ propene —step **3**→ poly(propene)

Naphtha is a mixture of alkanes with 6 to 12 carbon atoms per molecule.

For each step, name the process and state briefly the purpose of the process that leads to the formation of poly(propene).

[6 marks]

Step **1**

Name _____

Purpose _____

_____

_____

Step **2**

Name _____

Purpose _____

_____

_____

Step **3**

Name _____

Purpose _____

_____

_____

Do not write outside the box

0 5 . 2 Poly(propene) is not biodegradable because it is unreactive.

Explain why poly(propene) is unreactive.

[1 mark]

0 5 . 3 Scientists are developing new polymers, including some that are biodegradable.

Suggest why it is beneficial for some polymers to be biodegradable.

[1 mark]

8

Turn over for the next question

Question	Marking guidance	Additional Comments/Guidelines	Mark
05.1	**Step 1** **M1** fractional distillation **M2** separated into mixtures of compounds with similar boiling points / similar sized molecules **Step 2** **M3** (thermal) cracking **M4** to make alkenes / propene **/** shorter molecules **Step 3** **M5** (addition) polymerisation **M6** molecules joined together or to produce long chain molecule	For each step the two marks are independent **M2** to separate naphtha from other compounds; to separate compounds by chain length / size / boiling point **M3** not catalytic cracking **M5** not condensation polymerisation	1 1 1 1 1 1

Question	Marking guidance	Additional Comments/Guidelines	Mark
05.2	no polar bonds (in chain) / non-polar	Do not allow if only C-H bonds mentioned as non polar	1

Question	Marking guidance	Additional Comments/Guidelines	Mark
05.3	to prevent build-up of waste (in landfill) OR they can be broken down by natural processes		1

Do not write outside the box

0 5 This question is about the synthesis of propylamine ($CH_3CH_2CH_2NH_2$) by the reaction of 1-iodopropane ($CH_3CH_2CH_2I$) with an excess of ammonia.

$$CH_3CH_2CH_2I + 2\,NH_3 \rightarrow CH_3CH_2CH_2NH_2 + NH_4I$$

0 5 . 1 Name and outline the mechanism for this reaction.

[5 marks]

Name of mechanism _____

Outline of mechanism

Do not write outside the box

0 5 . 2 1-iodopropane is a liquid at room temperature.

Calculate the number of molecules in 5.0 cm^3 of 1-iodopropane (M_r = 169.9). Give your answer in standard form.

For 1-iodopropane, density = 1.75 g cm^{-3}

The Avogadro constant, L = 6.022 x 10^{23} mol^{-1}

[2 marks]

Number of molecules _____

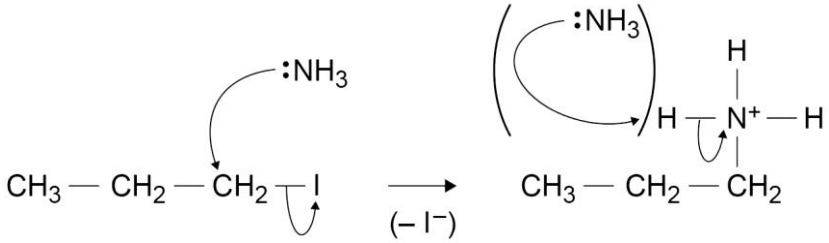
0 5 . 3 In an experiment, 10.3 g of 1-iodopropane (M_r = 169.9) are reacted with an excess of ammonia. 2.3 g of propylamine (M_r = 59.0) are produced.

Calculate the percentage yield in this experiment.

[2 marks]

Percentage yield _____

9

Question	Marking guidance	Additional Comments/Guidelines	Mark
05.1	**M1** nucleophilic substitution  **M2** attack by NH_3: arrow from lone pair on N of NH_3 towards C of C-I bond **M3** breaking of C-I bond: arrow from C-I bond to I **M4** structure of intermediate **M5** loss of H^+: arrow from N-H bond to N	Penalise **M3** for formal charge on C and / or I of C-I or incorrect partial charges on C-I**;** ignore other partial charges on uncharged atoms **M4** is independent For **M5** there is no need to show attack by a second NH_3 molecule, but if it is shown, it must be correct (but, if the NH_3 is charged and has been penalised in **M2** (or **M3** for SN1), then do not penalise the same error again in **M5**); penalise removal of H^+ by attack with I^- For SN2: penalise **M2** for any additional arrow or charge on NH_3; penalise **M3** for any additional arrow(s) to / from the I to / from anything else If SN1 mechanism given (loss of I first followed by attack by NH_3): **M2** curly arrow from C-I bond to the I **M3** curly arrow from lone pair on N of NH_3 to positive C atom of correct carbocation penalise **M2** for any additional arrow(s) to / from the I to / from anything else penalise **M3** for any additional arrow or charge on NH_3	1 1 1 1 (5 x AO1)

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05.2	**M1** amount of 1-iodopropane = $\frac{5.0 \times 1.75}{169.9}$ (= 0.0515 mol) **M2** number of molecules = **M1** x 6.022×10^{23} = 3.1(0)-3.13(144) x 10^{22}	Allow ECF from **M1** to **M2** based on an attempt to find the amount of 1-iodopropane in moles using the M_r **M2** Answer must be standard form (and be at least 2sf)	1 1 (2 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
05.3	**M1** amount of propylamine = $\frac{2.3}{59.0}$ (= 0.0390 mol) **AND** amount of 1-iodopropane = $\frac{10.3}{169.9}$ (= 0.0606 mol) **M2** % yield = ($\frac{0.0390}{0.0606} \; x \; 100$) = 63.9 to 64(.4 %)	Correct answer scores 2 marks Allow ECF from **M1** to **M2** Alternative method **M1** mass of 1-iodopropane = $\frac{10.3 \times 59.0}{169.9}$ (= 3.58 g) **M2** % yield = ($\frac{2.3}{M1} \; x \; 100$) = 63.9 to 64(.4 %)	1 1 (2 x AO2)

Do not write outside the box

0 6 Trichlorofluoromethane (CCl_3F) was developed as a refrigerant. The production and use of CCl_3F is now restricted.

0 6 . 1 The equation for a process used to manufacture CCl_3F is

$$SbF_3Br_2 + CCl_4 \rightarrow CCl_3F + SbF_2Br_2Cl$$

Calculate the percentage atom economy for the production of CCl_3F in this reaction. Give your answer to 3 significant figures.

[2 marks]

Percentage atom economy _____

An alternative synthesis of CCl_3F is the free-radical substitution reaction between fluoromethane (CH_3F) and chlorine.

0 6 . 2 An intermediate in this alternative synthesis is dichlorofluoromethane ($CHCl_2F$)

Give equations to represent the two propagation steps in the conversion of $CHCl_2F$ into CCl_3F

[2 marks]

Propagation step 1

_____

Propagation step 2

_____

Do not write outside the box

0 6 . 3 Analysis of the products of this reaction shows the formation of a compound with the empirical formula CCl_2F

Give an equation to represent a termination step forming this compound.
Show the structural formula of the product in the equation.

[1 mark]

5

Turn over for the next question

Question	Marking guidance	Additional Comments/Guidelines	Mark
06.1	**M1** $\frac{137.5}{492.6}$ or $\frac{12.0 + 3(35.5) + 19.0}{121.8 + 3(19.0) + 2(79.9) + 12.0 + 4(35.5)}$ or $\frac{137.5}{338.6 + 154.0}$ $\frac{12.0 + 3(35.5) + 19.0}{12.0 + 3(35.5) + 19.0 + 121.8 + 2(19.0) + 2(79.9) + 35.5}$ or $\frac{137.5}{355.1 + 137.5}$ **M2** **(**x 100) = 27.9 (%)	**M2** must be 3 sig figs Correct answer scores 2 marks Can score 1 mark for 137.5 (or working that gives this) or 492.6 (or working that gives this) in working if no other marks scored	1 1 (2 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
06.2	**M1** $CHCl_2F + \bullet Cl \rightarrow \bullet CCl_2F + HCl$ **M2** $\bullet CCl_2F + Cl_2 \rightarrow CCl_3F + \bullet Cl$	Allow equations in either order Allow dot anywhere on the correct radical Ignore extra initiation and termination steps Penalise absence of dots once only	1 1 (2 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
06.3	2 $\bullet CCl_2F \rightarrow CCl_2FCCl_2F$	Allow dot anywhere on the radical Structural formula of product must be shown in answer (ignore additional correct molecular formula)	1 (AO3)