Alkanes: Formulae, Reactions & Structure

Mark Scheme 2

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	The Core Principles of Chemistry
Sub Topic	Alkanes: Formulae, Reactions & Structure
Booklet	Mark Scheme 2

Time Allowed: **54 minutes**

Score: **/45**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

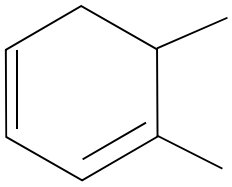
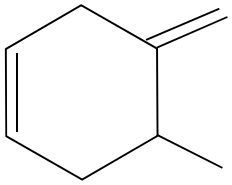
Question Number	Acceptable Answers	Reject	Mark
1(a)	Fractional distillation Both words needed		**1**

Question Number	Acceptable Answers	Reject	Mark
1(b)(i)	C_9H_{20}		**1**

Question Number	Acceptable Answers	Reject	Mark
1(b)(ii)	Correct skeletal formula **(1)** Correct name for the structure drawn providing that the structure is a branched-chain isomer of C_9H_{20} **NO TE for name if skeletal formula is incorrect** **ALLOW** Correct name, even if structural or displayed formula has been drawn **(1)** EXAMPLES of correct skeletal formulae and names  2-methyloctane  3-methyloctane  4-methyloctane	Structural or displayed formula	**2**

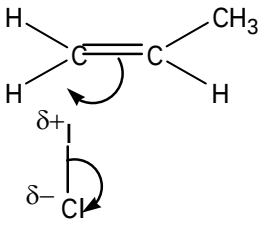
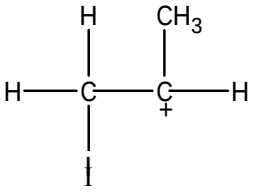
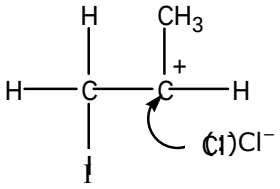
Question Number	Acceptable Answers	Reject	Mark
1(c)(i)	$C_{15}H_{32} \rightarrow C_{13}H_{28} + C_2H_4$ **IGNORE** State symbols, even if incorrect **ALLOW** Correct structural OR displayed OR skeletal OR mixture of these (as long as unambiguous)		**1**

Question Number	Acceptable Answers	Reject	Mark
1(c)(ii)	Any **carbon-carbon bond** (in the chain) can **break** OR The **carbon chain** can **break**/**split** in different places OR Carbon chain is cracked in many places / different places OR $C_{13}H_{28}$ / product will break down further **IGNORE** 'Molecule can break anywhere' / 'It breaks into smaller molecules' / 'large number of C atoms' / 'bonds break randomly' / 'hydrocarbon chain is long'		**1**

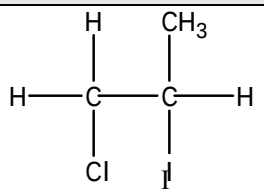
Question Number	Acceptable Answers	Reject	Mark
1(d)(i)	Two double bonds anywhere on the RING (allow them to be adjacent). e.g.  **ALLOW** One triple bond (instead of two double bonds) BUT not adjacent to a methyl group **ALLOW:** (ie double bond(s) on side-chain) 	If any other incorrect structure is included with the final answer Any 5-valent C atom in structure scores **(0)** If the methyl groups are joined by a bond **(0)** Benzene ring **(0)**	**1**

Question Number	Acceptable Answers	Reject	Mark
1(d)(ii)	**NOTE** The answer must relate to combustion or burning To promote efficient combustion OR To increase octane number OR To reduce knocking OR Pre-ignition less likely **ALLOW** To allow smoother burning OR More efficient fuels OR Better burning / fuels easier to burn OR Combust more easily OR Improves combustion **ALLOW** Reverse argument for straight-chain hydrocarbons **IGNORE** References to: 'less pollution' / 'burning more cleanly' / 'better fuels' / 'to form alkenes' / 'to form more useful products' /'branched chains form' / boiling point / volatility / 'to form H_2'	'Ignition less likely' **(0)**	**1**

(Total for Question 1 = 8 marks)

Question Number	Acceptable Answers	Reject	Mark
2(a)(i)	Curly arrow from double bond towards iodine atom **AND** curly arrow from the I—Cl **bond** to the chlorine atom **(1)**  Carbocation intermediate **(1)**  Curly arrow from the chloride ion to the correct C^+ in the intermediate **(1)**  **NOTE** Curly arrow can originate from anywhere on the Cl^- ion in the final step. Do not have to have a lone pair of e^- on the Cl^- ion	δ^+ for + δ^- for – on Cl^-	**3**

Question Number	Acceptable Answers	Reject	Mark
2(a)(ii)	Electrophilic **(1)** Addition **(1)** ALLOW answers in either order IGNORE 'heterolytic'		**2**

Question Number	Acceptable Answers	Reject	Mark
2(a)(iii)	 ALLOW Correct structural OR displayed OR skeletal formula OR mixture of these (so long as unambiguous) Eg $CH_2ClCHICH_3$ IGNORE Any name given, even if incorrect		**1**

Question Number	Acceptable Answers	Reject	Mark
2(b)(i)	Ultraviolet / UV OR Sun (light) OR Light **ALLOW** **High** temperature / 300°C (minimum) IGNORE Just heat / just radiation / rays	Mention of a 'catalyst'	**1**

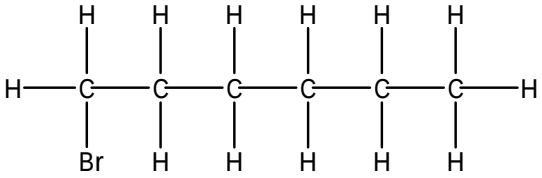
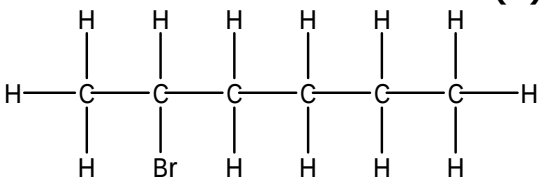
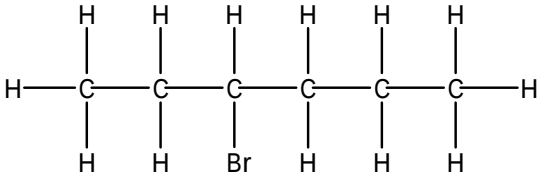
Question Number	Acceptable Answers	Reject	Mark
2(b)*(ii)	**First mark:** (Free) radical substitution **(1)** **Second mark:** **Homolytic** (fission) **(1)** **Third mark:** **Initiation** **AND** $ICl \rightarrow I\bullet + Cl\bullet$ **(1)** BOTH needed for the 3rd mark **Fourth mark:** **Propagation** **(1)** **Fifth and sixth marks:** $CH_4 + Cl\bullet \rightarrow CH_3\bullet + HCl$ **(1)** $CH_3\bullet + ICl \rightarrow CH_3I + Cl\bullet$ **(1)** **IGNORE** $CH_4 + I\bullet \rightarrow CH_3\bullet + HI$ $CH_3\bullet + ICl \rightarrow CH_3Cl + I\bullet$ **Seventh mark:** $CH_3\bullet + I\bullet \rightarrow CH_3I$ OR $Cl\bullet + Cl\bullet \rightarrow Cl_2$ OR $CH_3\bullet + Cl\bullet \rightarrow CH_3Cl$ OR $CH_3\bullet + CH_3\bullet \rightarrow C_2H_6$ OR $I\bullet + Cl\bullet \rightarrow ICl$ ALLOW $I\bullet + I\bullet \rightarrow I_2$ **(1)** **IGNORE** **Any** INCORRECT termination step(s) **IGNORE** State symbols, even if incorrect Curly arrows / half curly arrows, even if incorrect	**Heterolytic** (fission) H• (the fifth and sixth marks cannot be awarded if H• appears in **either** propagation step)	**7**

(Total for Question 2 = 14 marks)

Question Number	Acceptable Answers	Reject	Mark
3 (a)(i)	Penalise use of chlorine once only in Q21(a)(i), (ii) and (iii) IGNORE lone pairs of electrons, even if incorrect in Q21(a)(i), (ii) and (iii) ALLOW one slip in the formula of the element if it is correctly given elsewhere in the answer e.g B for Br $Br_2 \rightarrow Br\bullet + Br\bullet$ / $Br_2 \rightarrow 2Br\bullet$ Ignore position of dot Ignore state symbols and curly arrows even if incorrect	Br	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(ii)	$Br_2 \rightarrow Br^+ + Br^-$ Ignore state symbols and curly arrows even if incorrect	$\boldsymbol{\delta^+}$ / $\boldsymbol{\delta^-}$ for the + or −	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(iii)	(free radical) Br• NOTE: No TE, except Cl• **(1)** Penalise omission of the dot only once in (a)(i) and (a)(iii) (electrophile) $\boldsymbol{Br^+}$ NOTE: No TE, except Cl^+ **(1)**	Br	**2**

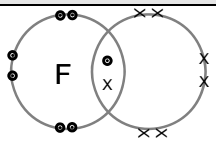
Question Number	Acceptable Answers	Reject	Mark
3 (b)(i)	 **(1)**  **(1)**  **(1)** Isomers can be in any order ALLOW skeletal or structural formulae	Any branched-chain isomers	**3**

Question Number	Acceptable Answers	Reject	Mark
3 (b)(ii)	Corrosive / toxic / poisonous Allow correct symbols for corrosive or toxic / poisonous   IGNORE harmful / dangerous / irritant / acidic / volatile / any references to state of HBr IGNORE Any precautions taken, EXCEPT those related to flammability	Flammable / 'naked flames'	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (b)(iii)	**First mark** Calculation of the $C_6H_{13}Br$ M_r value and the total of the product Mr EXPECTED 164.9 **AND** 245.8 ALLOW 165 **AND** 246 **(1)** **Second mark** EXPECTED $\frac{164.9}{245.8}$ (x 100%) = 67.08706265(%) **= 67.1(%) to 3 s.f.** ALLOW $\frac{165}{246}$ (x 100%) = 67.07317073 (%) = **67.1(%) to 3 s.f.** ALLOW TE from any incorrect M_r value(s) provided answer is not greater than 100% **(1)** Answer **MUST** be rounded correctly to 3 s.f. for the second mark Correct answer with no working **(2)**		**2**

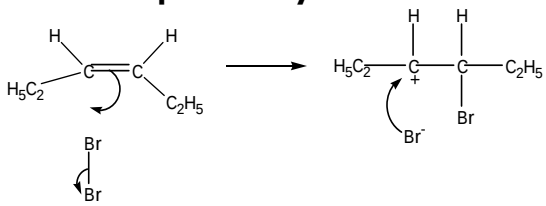
Question Number	Acceptable Answers	Reject	Mark
3 (c)(i)	$CH_4 + F_2 \rightarrow CH_3F + HF$ IGNORE state symbols, even if incorrect	Cl_2 "Fl" if used more than once	**1**

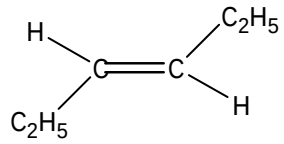
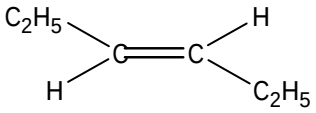
Question Number	Acceptable Answers	Reject	Mark
3 (c)(ii)	NOTE Allow reverse argument throughout **1st Mark** Fluorine / F (atom is) **smaller** (than a Cl atom) **(1)** **2nd Mark** Any ONE of:- (so expect) F—F **bond** to be shorter (than the Cl—Cl bond) OR F—F **bonding** electrons / **bond** pair / / **shared** pair closer to (both) nuclei OR (so) attraction between nuclei and **bonding** electrons / **bond** pair / **shared** pair expected to be stronger **(1)** IGNORE Any references to the strengths of the F-F and/or Cl-Cl bonds Any references to the 'repulsion between nuclei' Any references to 'shielding' / 'Charge density' / 'Electronegativity' / outer electrons	F_2 / 'fluorine **molecule**' Mention of 'Intermolecular forces' (no **2nd** mark)	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (c)(iii)	 Shared pair of electrons shown **(1)** The remaining six electrons on each F atom **(1)** NOTE Can be dots or crosses – only total number of electrons matters Circles not required IGNORE Two inner-shell electrons ALLOW 'Fl' or F symbol missing		**2**

Question Number	Acceptable Answers	Reject	Mark
3 (c)(iv)	**'Repulsion** between electrons' scores (1) BUT **'Repulsion** between lone pairs (of electrons)' scores (2) ALLOW 'Non-bonding electrons' for lone pairs	Just repulsion between bonding / shared electrons	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (c)(v)	UV (light) / (sun) light / heat / energy required to break Cl—Cl bond OR UV (light) / (sun) light / heat / energy required to form Cl• OR F—F requires less energy to break OR F—F requires less energy to form F• IGNORE **Just** F_2 more reactive (than Cl_2) **Just** F—F bond is weaker (than Cl—Cl) **Just** F—F bond energy is lower (than Cl—Cl)		**1**

Question Number	Acceptable Answers	Reject	Mark
3 (d)	**Mark independently**  **First mark:** For **both arrows** in initial step Allow upper arrow as in diagram or directly to Br atom **(1)** **Second mark:** Carbocation intermediate **(1)** **Third mark:** Arrow from anywhere on the bromide ion to the C or to the + sign on the intermediate **(1)** Lone pair(s) on Br^- not required	**Half-arrow(s)** **Incorrect polarities** **Full**-charges on Br_2 **Half-arrow(s)** **δ⁻** instead of the full **–** sign on the Br^-	**3**

Question Number	Acceptable Answers	Reject	Mark
3(e)(i)	 OR  Diagram **clearly shows** that H atoms are diagonal to each other in the *E*-isomer/correct relative positions of hydrogen atoms and ethyl groups ALLOW Skeletal or displayed formula		**1**

Question Number	Acceptable Answers	Reject	Mark
3(e)(ii)	EITHER **Rotation** around C—C bond (in product molecule) OR Double bond is broken so **rotation** (is now possible) ALLOW Same carbocation / intermediate formed (so product is the same) IGNORE Comments about optical isomerism		**1**

(Total for Question 3 = 23 marks)