OCR
RECOGNISING ACHIEVEMENT

GCE

# Chemistry A

Advanced Subsidiary GCE

Unit **F322:** Chains, Energy and Resources

# Mark Scheme for June 2013

Oxford Cambridge and RSA Examinations

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

## Annotations

Annotations available in Scoris.

| Annotation | Meaning |
|---|---|
| BOD | Benefit of doubt given |
| CON | Contradiction |
|  | Incorrect response |
| ECF | Error carried forward |
| I | Ignore |
| NAQ | Not answered question |
| NBOD | Benefit of doubt not given |
| POT | Power of 10 error |
| ^ | Omission mark |
| RE | Rounding error |
| SF | Error in number of significant figures |
|  | Correct response |
| SEEN | Noted but no credit given |
| REP | Repeat |

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

| Annotation | Meaning |
|---|---|
| **DO NOT ALLOW** | Answers which are not worthy of credit |
| **IGNORE** | Statements which are irrelevant |
| **ALLOW** | Answers that can be accepted |
| ( ) | Words which are not essential to gain credit |
| __ | Underlined words must be present in answer to score a mark |
| **ECF** | Error carried forward |
| **AW** | Alternative wording |
| **ORA** | Or reverse argument |

All questions should be annotated with ticks to show where marks have been awarded in the body of the text.

All questions where an ECF has been applied should also be annotated with the ECF annotation.

Use the omission mark where the answer is not sufficient to be awarded a mark.

## Generic comments

**ORGANIC STRUCTURES**

For a 'structure' or 'structural formula',

- **ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous)

For an alkyl group shown within a structure,

- **ALLOW** bond drawn to C or H,

eg **ALLOW** $CH_3$–,$CH_2$–, $C_3H_7$–, etc

- **ALLOW** vertical 'bond' to any part of an alkyl group

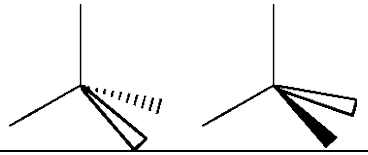
For an OH group shown within a structure,

- **DO NOT ALLOW** formula with horizontal —HO **OR** —HO
- **ALLOW** vertical 'bond' to any part of the OH group

For a CHO group shown within a structure,

- **DO NOT ALLOW** COH

For a 3D structure,

| | |
|---|---|
| • For bond in the plane of paper, a solid line is expected: |  |
| • For bond out of plane of paper, a solid wedge is expected: |  |
| • For bond into plane of paper, **ALLOW**: |  |
| • **ALLOW** a hollow wedge for 'in bond' OR an 'out bond', provided it is different from the other in or out wedge eg: |  |

**NAMES**

Names including alkyl groups:

- **ALLOW** alkanyl, eg ethanyl (ie **IGNORE** 'an')
- **DO NOT ALLOW** alkol, eg ethol (ie 'an' is essential)

Names of esters:

- Two words are expected, eg ethyl ethanoate
- **ALLOW** one word, eg ethylethanoate

Names with multiple numbers and hyphens:

Use of 'e'

- **ALLOW** superfluous 'e' , eg propane-1-ol ('e' is kept if followed by consonant)
- **ALLOW** absence of 'e', eg propan-1,2-diol ('e' is omitted if followed by vowel)

Hyphens separate name from numbers:

- **ALLOW** absence of hyphens, eg propane 1,2 diol

Multiple locant numbers must be clearly separated:

- **ALLOW** full stops: eg 1.2 OR spaces: 1 2
- **DO NOT ALLOW eg** 12

Locant numbers in formula must be correct

- **DO NOT ALLOW** propan-3-ol

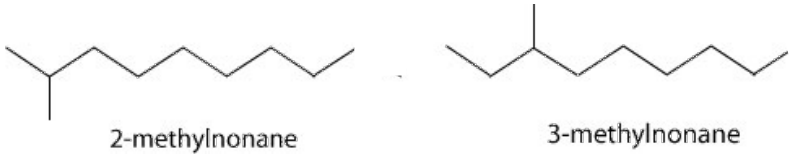
Order of substituents should be alphabetical:

- **ALLOW** any order (as long as unambiguous), eg 2-chloro-3-bromobutane

**ABBREVIATIONS**

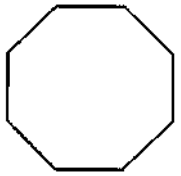
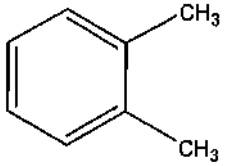
van der Waal's forces

**ALLOW** vdw forces **OR** VDW forces (and any combination of upper and lower cases)

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 1 | (a) | (i) | $C_{10}H_{22}$ ✓ | 1 | **IGNORE** the name decane |
| | | (ii) | Correct skeletal formula ✓<br><br>Correct name for structure drawn providing the structure is a branched chain isomer of $C_{10}H_{22}$ ✓ | 2 | **DO NOT ALLOW** structural formula **OR** displayed formula<br><br>Examples of skeletal formulae:<br>  <br><br><br>**ALLOW** name even if structural or displayed formula drawn<br><br>**DO NOT ALLOW** incorrect nomenclature eg 2-ethyloctane, 6-methylnonane, 2-methnonane, 2-methylnonan, 2-methynonane<br><br>There are many more isomers that can be drawn |

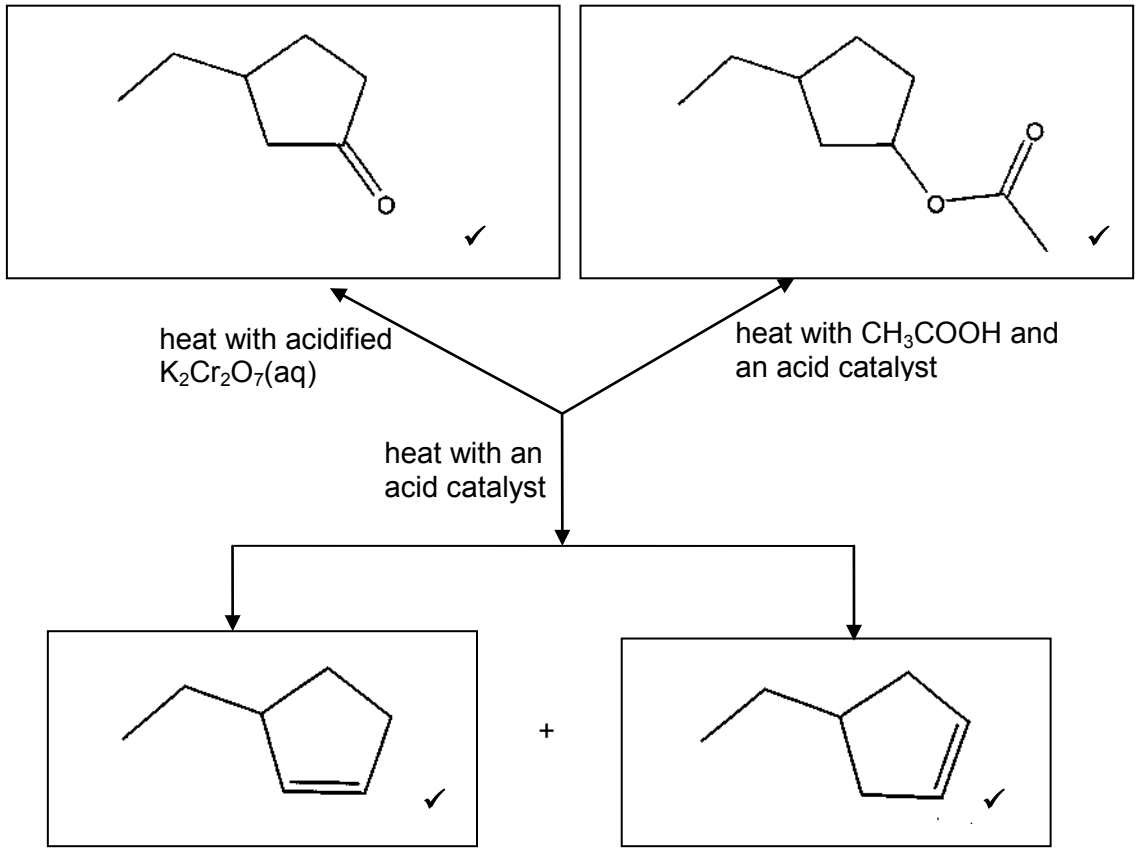
| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 1 | (a) | (iii) | **B** has less surface (area of) contact **OR** ORA<br>**AND**<br>**B** has fewer **van der Waals**' forces **OR B** has weaker **van der Waals**' forces **OR** ORA ✓ | 2 | **Both answers need to be comparisons**<br>Assume 'it' refers to **B**<br><br>**ALLOW B** has less points of contact **AND** fewer VDW<br><br>**DO NOT ALLOW** less points of contact between atoms<br><br>Reference to just surface area or closeness of molecules is **not** sufficient. **IGNORE** if not qualified<br><br>**IGNORE B** more compact **OR B** has a shorter chain<br><br>**DO NOT ALLOW B** is a smaller molecule<br>**DO NOT ALLOW B** has fewer electrons<br><br>Intermolecular forces is **not** sufficient for the first marking point must refer to van der Waals'<br><br>**ALLOW** ORA throughout in terms of **A** if specified |
| | | | So less energy needed to break the intermolecular forces in **B OR** ORA ✓ | | **ALLOW** in **B** it takes less energy to overcome the intermolecular forces<br><br>**ALLOW** it is easier to overcome the intermolecular forces<br><br>**DO NOT ALLOW** so less energy is needed to break bonds<br><br>**DO NOT ALLOW** intermolecular bonds |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 1 | (b) | (i) | Correct equation for the cracking of $C_{15}H_{32}$ ✓<br>eg $C_{15}H_{32} \rightarrow C_{13}H_{28} + C_2H_4$ | 1 | **ALLOW** molecular formula **OR** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous)<br><br>**ALLOW** any correct equation that has an alkane and alkene(s) (and hydrogen) as products **OR** has alkenes and hydrogen as products<br>e.g. $C_{15}H_{32} \rightarrow C_{11}H_{24} + 2C_2H_4$<br>$C_{15}H_{32} \rightarrow C_6H_{12} + C_9H_{18} + H_2$<br><br>**IGNORE** state symbols |
| | | (ii) | (idea that) any **carbon–carbon** bond (in the chain) can break ✓ | 1 | **ALLOW carbon chain** can break in many different places<br><br>**ALLOW** the position of breakdown of the **carbon chain** is random<br><br>**ALLOW** the **carbon chain** can break in many different places<br><br>**ALLOW** carbon chain can split in many different places<br><br>Carbon chain is cracked in many places is **not** sufficient<br><br>Molecule can break anywhere is **not** sufficient / cannot control where the molecule breaks is not sufficient<br><br>Molecule can form many different chain lengths is **not** sufficient |

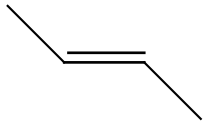
| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 1 | (c) | (i) | Any cyclic hydrocarbon with eight carbon atoms in all ✓<br>eg<br>  <br>  <br> | 1 | **ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous)<br><br>**ALLOW** equation with the correct product<br><br>**DO NOT ALLOW** if any other extra structure is included which is incorrect<br><br>**DO NOT ALLOW** 'aromatic cyclooctatetraene' but **ALLOW** this as a normal structural formula<br><br>**IGNORE** hydrogen as an extra product<br><br>**IGNORE** any name given |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 1 | (c) | (ii) | Cyclic hydrocarbons promote efficient combustion ✓ | 1 | **The answer must relate to combustion or burning**<br><br>**ALLOW** cyclic hydrocarbons allow smoother burning<br>**OR** cyclic hydrocarbons increase octane number<br>**OR** cyclic hydrocarbons reduce knocking<br>**OR** cyclic hydrocarbons are less likely to produce pre-ignition<br>**OR** cyclic hydrocarbons are more efficient fuels<br>**OR** cyclic hydrocarbons burn better **OR** easier to burn<br>**OR** cyclic hydrocarbon combust more easily<br>**OR** improves combustion<br>**DO NOT ALLOW** cyclic hydrocarbons ignite more easily<br><br>**ALLOW** ora for straight chain hydrocarbons<br><br>**IGNORE** cyclic hydrocarbons increase volatility of fuel<br>**IGNORE** cyclic hydrocarbons have a lower boiling point<br><br>Cyclic hydrocarbons are a better fuel on their own is **NOT** sufficient<br>Cyclic hydrocarbons burn more cleanly on their own is **NOT** sufficient |
| | | | **Total** | **9** | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 2 | (a) | (i) | **E** and **H** ✓ | 1 | **ALLOW** pentan-2-ol **and** 2-methylbutan-2-ol |
| | | (ii) | **H** ✓ | 1 | **ALLOW** 2-methylbutan-2-ol |
| | | (iii) | **F** ✓ | 1 | **ALLOW** propan-1-ol |
| | (b) | (i) | $C_5H_{10}O$ ✓ | 1 | **ALLOW** any order of atoms<br><br>**DO NOT ALLOW** $C_5H_9OH$ |
| | | (ii) | 2-methylpentan-3-ol ✓ | 1 | **ALLOW** 2-methylpentane-3-ol<br><br>**ALLOW** absence of hyphens or use of commas<br><br>**ALLOW** space between methyl and pentan<br><br>**DO NOT ALLOW** 2-methylpent-3-ol **OR** 2-methypentan-3-ol **OR** 2-metpentan-3-ol, 4-methylpentan-3-ol etc |
| | (c) | | (series of compound) with same functional group ✓<br><br>and each **successive** member differing by $CH_2$ ✓ | 2 | **IGNORE** with same or similar chemical properties **OR** same or similar chemical reactions<br><br>**IGNORE** references to physical properties or named physical properties vary with an observable trend.<br><br>**IGNORE** have similar or the same physical properties<br><br>**IGNORE** has same general formula<br><br>**ALLOW** each subsequent member varying by $CH_2$<br><br>**DO NOT ALLOW** have the same empirical formula **OR** have the same molecular formula |

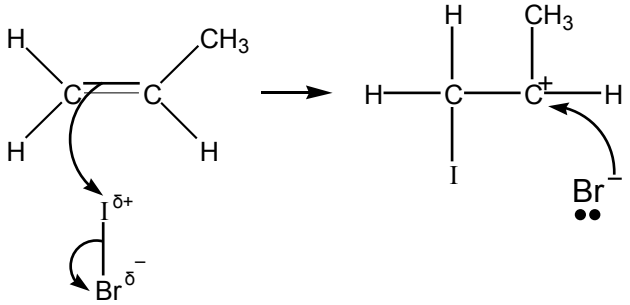
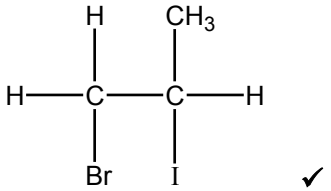
| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 2 | (d) | |  | 4 | **ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous)<br><br>**IGNORE** inorganic products if written in, eg $H_2O$ for the elimination reactions<br><br>**IGNORE** names of compounds<br><br>**ALLOW** in either order |
| | | | **Total** | **11** | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 3 | (a) | | alkene ✓<br><br>ester ✓ | 2 | **ALLOW** carbon–carbon double bond **OR** a C-C double bond<br><br>A double bonded carbon is **not** sufficient<br>C=C is **not** sufficient<br>Carbon-carbon multiple bond is **not** sufficient<br><br>Ketone / carbonyl / aldehyde / carboxylic acid contradicts the ester mark |
| | (b) | | contains a C=C bond ✓ | 1 | Contains a double bond is **not** sufficient<br>Carbon-carbon multiple bond is **not** sufficient<br>**DO NOT ALLOW** contains a C=O bond |
| | (c) | | (from) orange (to) colourless ✓ | 1 | **ALLOW** shades of orange **OR** yellow **OR** brown<br>**ALLOW** orange to decolourised<br><br>**DO NOT ALLOW** red alone<br>**DO NOT ALLOW** any response that includes precipitate **OR** solid, irrespective of colour<br>**DO NOT ALLOW** clear for colourless |
| | (d) | (i) | Same structural formula<br>**AND**<br>different arrangement (of atoms) **in space OR** different **spatial** arrangement ✓ | 1 | **ALLOW** have the same structure/displayed formula/skeletal formula<br><br>**DO NOT ALLOW** same empirical formula **OR** same general formula<br><br>Stereoisomers have the same formula or molecular formula is **not** sufficient<br>Different three dimensional arrangement is **not** sufficient<br>Reference to *E*/*Z* isomerism or optical isomerism is **not** sufficient |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 3 | (d) | (ii) |  ✓ | 1 | **Any writing must not contradict the diagram**<br><br>**IGNORE** any other feature of the structure drawn<br><br>**ALLOW** the **J** will be the *E* isomer and **I** is the *Z* isomer<br><br>**ALLOW** the **J** will be the *trans* isomer and **I** is the *cis* isomer<br><br>**ALLOW** a description, eg the other isomer will have (carbon) chains diagonally arranged across the C=C or the other isomer will have hydrogen atoms diagonally arranged across the C=C bond<br><br>**DO NOT ALLOW** draw *trans* but label as *cis* |
| | **(e)** | **(i)** | (Enthalpy change that occurs) when one mole of a substance ✓<br><br>completely combusts **OR** reacts fully with oxygen ✓ | 2 | **ALLOW** energy required **OR** energy released<br><br>**ALLOW** (energy change) when one mole of an element / compound / molecule / reactant<br><br>**DO NOT ALLOW** one mole of reactant**s** / product / substance**s** / fuel / atoms<br><br>**ALLOW** combusts in excess oxygen<br>**ALLOW** burns in excess oxygen<br><br>**DO NOT ALLOW** combust in excess air<br><br>**IGNORE** fully oxidised<br><br>**IGNORE** any conditions stated |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 3 | (e) | (ii) | **FIRST, CHECK THE ANSWER ON ANSWER LINE**<br>**IF** answer = 7.06(42), award **2 marks.**<br>**IF** answer = 7.1, award **1 mark.**<br><br>$q$ = 50.0 × 4.18 × 33.8 **OR** 7064.2 (J) ✓<br><br>= 7.06(42) (kJ) ✓ | 2 | <br><br><br><br>**ALLOW** 7.06 up to calculator value of 7.0642 correctly rounded<br><br>**DO NOT ALLOW ECF** from marking point 1<br>**IGNORE** negative sign in answer |
| | | (iii) | **FIRST, CHECK THE ANSWER ON ANSWER LINE**<br>**IF** answer = 0.005(00), award **2 marks.**<br><br>$M_r$ = 268.0 ✓<br><br>amount used = 0.005(00) (mol) ✓ | 2 | **IF** there is an alternative answer, check to see if there is any **ECF** credit possible using working below<br><br>**ALLOW** 268<br><br>**ALLOW** 5 x $10^{-3}$<br>**ALLOW** ECF from incorrect $M_r$<br>**IGNORE** trailing zeros |
| | | (iv) | **FIRST, CHECK THE ANSWER ON ANSWER LINE**<br>**IF** answer = -1413, award **3 marks.**<br>**IF** answer = 1413, award **2 marks.**<br><br>$\Delta H = \frac{\text{answer to (ii)}}{\text{answer to (iii)}}$ **OR** $\frac{7.0642}{0.005}$ ✓<br><br>1413 ✓<br><br>minus sign (this is an independent mark) ✓ | 3 | **IF** there is an alternative answer, check to see if there is any **ECF** credit possible using working below<br><br>**ALLOW** ECF from **(ii)** and **(iii)**<br><br>**ALLOW** 1410 up to calculator value of 1412.84 correctly rounded<br>**ALLOW** answers in standard form 1.41 x $10^3$ up to calculator value of 1.41284 x $10^3$ correctly rounded<br><br>Answer must be at least **three** significant figures<br><br>**ALLOW** 1412 if answer to (ii) is 7.06<br>**ALLOW** 1420 if answer to (ii) is 7.1 |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 3 | (e) | (v) | incomplete combustion **OR** not sufficient oxygen available **AND** carbon is formed ✓ | 1 | **IGNORE** soot is formed, carbon monoxide is formed or carbon dioxide is formed |
| | (f) | | $C_6H_{12}O_6 \rightarrow 2CO_2 + 2C_2H_5OH$ ✓ | 3 | **ALLOW** correct molecular **OR** structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous)<br>**IGNORE** state symbols |
| | | | use of yeast **OR** zymase ✓ | | Enzyme is **not** sufficient<br>**DO NOT ALLOW** acid catalyst |
| | | | anaerobic **OR** absence of oxygen **OR** any temperature between 20 and 45 $^{o}$C **OR** water **OR** aqueous ✓ | | **If there is a contradiction or an incorrect answer in any condition given then do not award this mark.**<br><br>**ALLOW** room temperature<br>Temperature quoted **must** include unit<br><br>**ALLOW** conditions shown in the equation<br><br>**IGNORE** warm temperature<br>**IGNORE** heat / warm<br><br>Body temperature is **not** sufficient<br>A limited supply of oxygen is **not** sufficient<br><br>**IGNORE** low pressure **OR** atmospheric pressure<br>**DO NOT ALLOW** high pressure **OR** a pressure above 2 atmospheres |
| | | | **Total** | **19** | |

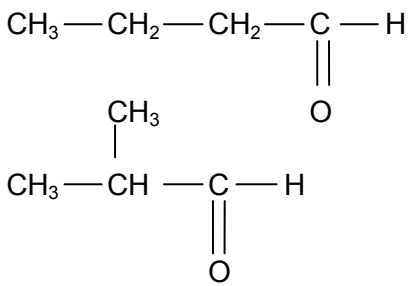
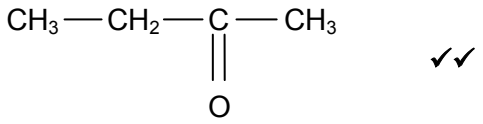
| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 4 | (a) | (i) | correct curly arrow from double bond to iodine atom and curly arrow from the I–Br bond to the bromine atom ✓<br><br>correct carbonium ion **OR** correct carbocation ✓<br><br>correct curly arrow from bromide ion to the (positive) carbon ✓<br><br>  | 3 | Curly arrow must start from bond and go to correct atom<br>**DO NOT ALLOW** partial charges on carbon–carbon double bond<br><br>**DO NOT ALLOW** δ+ on carbon atom<br>The positive charge must be associated with the carbon atom and not with a bond<br>Make certain the carbonium ion includes the iodine atom<br><br>Curly arrow must come from any lone pair or the negative sign of the bromide ion<br><br>The lone pair on the bromide ion does not need to be shown |
| | | (ii) | Electrophilic addition ✓ | 1 | |
| | | (iii) |  ✓ | 1 | **ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) eg $CH_2BrCHICH_3$<br><br>**IGNORE** any name given |

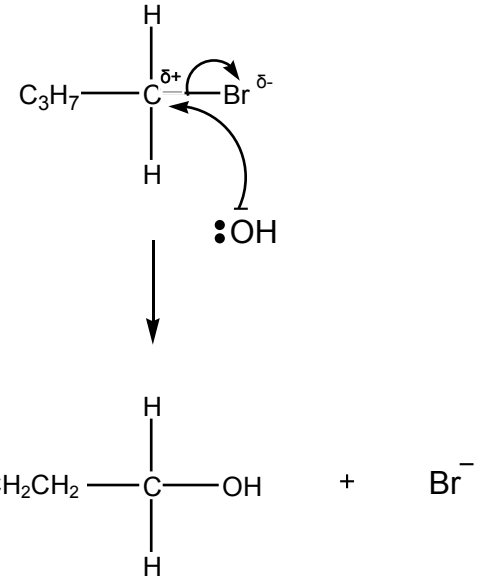
| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| | (b) | (i) | Ultraviolet **OR** UV ✓ | 1 | **ALLOW** high temperature **OR** 300 $^{o}$C<br>**IGNORE** light/radiation<br>**DO NOT ALLOW** any catalyst |
| | | (ii) | | 7 | **Use the SEEN annotation on page 11 if blank or no credit can be given** |
| | | | (free) radical substitution ✓ | | **IGNORE** any state symbols in equations<br>Radicals do **NOT** need a single dot |
| | | | **(Initiation step)**<br>IBr → Br + I ✓ | | **IGNORE** dots |
| | | | homolytic fission ✓ | | **DO NOT ALLOW** homolytical fission<br>Heterolytic anywhere in the answer contradicts this mark |
| | | | **(Propagation steps)**<br>Br + $CH_4$ → HBr + $CH_3$ ✓ | | **IGNORE** I + $CH_4$ → HI + $CH_3$ |
| | | | $CH_3$ + IBr → $CH_3I$ + Br ✓ | | **IGNORE** $CH_3$ + IBr → $CH_3Br$ + I<br>**DO NOT ALLOW** equations with H **OR** any other incorrect equation (i.e. not one of the four propagation steps shown) |
| | | | **(Termination steps)**<br>I + $CH_3$ → $CH_3I$<br>**OR** Br + Br → $Br_2$<br>**OR** I + I → $I_2$<br>**OR** Br + $CH_3$ → $CH_3Br$<br>**OR** $CH_3$ + $CH_3$ → $C_2H_6$<br>**OR** I + Br → IBr ✓ | | **ALLOW** any other suitable termination steps<br>**DO NOT ALLOW** termination steps with H |
| | | | **QWC** propagation linked to **correct** equations<br>Br + $CH_4$ → HBr + $CH_3$<br>$CH_3$ + IBr → $CH_3I$ + Br<br>**AND** initiation linked to **correct** equation<br>IBr → Br + I ✓ | | **QWC** can only be given if marking points 2, 4 and 5 have been awarded |
| | | | **Total** | **13** | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 5 | (a) | | **FIRST, CHECK THE ANSWER ON ANSWER LINE**<br>**IF** answer = –4596, award **3 marks.**<br>**IF** answer = +4596 award **2 marks.** | 3 | **IF** there is an alternative answer, check to see if there is any **ECF** credit possible using working below |
| | | | (–)116 ✓ | | **ALLOW** 116<br>**OR** –4(+54) –5(–20)<br>**OR** –216 + 100 |
| | | | (–)4480 ✓ | | **ALLOW** 4480<br>**OR** 4(–394) + 12(–242)<br>**OR** –1576 – 2904 |
| | | | –4596 ✓ | | **ALLOW** ecf from $\Delta H_{products} - \Delta H_{reactants}$<br><br>**ALLOW for 2 marks**<br>(+)4596 (cycle the wrong way round)<br>**OR** –4364 ($\Delta H_{reactants}$ the incorrect sign)<br>**OR** (+)4364 ($\Delta H_{products}$ the incorrect sign)<br>**OR** –752 (moles not used for products)<br>**OR** –4514 (moles not used for reactants)<br><br>**ALLOW for 1 mark**<br>(+)752 (moles not used for products and the cycle the wrong way round)<br>**OR** (+)4514 (moles not used for reactants and the cycle the wrong way round)<br>**OR** –670 (moles not used for reactants and products)<br><br>**Note:** There may be other possibilities |

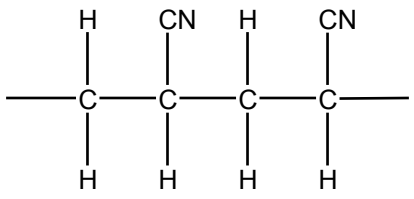
| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 5 | (b) | (i) | **FIRST, CHECK THE ANSWER ON ANSWER LINE**<br>**IF** answer = +820, award **2 marks.**<br>**IF** answer = –820 or +1640 award **1 mark.**<br><br>amount of $N_2O$ = 10 (mol) ✓<br><br>enthalpy change = (+)820 ✓ | 2 | **IF** there is an alternative answer, check to see if there is any **ECF** credit possible using working below<br><br>**ALLOW** ECF, ie moles of $N_2O$ x enthalpy of formation |
| | | (ii) | (+)82 ✓ | 1 | |
| | | (iii) | (+)283 ✓ | 1 | |
| | (c) | | $O_3 \rightarrow O_2 + O$ **AND** $O + O_2 \rightarrow O_3$ ✓<br><br>rate of ozone decomposition (almost) equals rate of ozone formation ✓ | 2 | **ALLOW** $O_3 \rightleftharpoons O_2 + O$<br>**ALLOW** $O_3 \rightarrow O_2 + O$ is reversible<br>**ALLOW** $O + O_2 \rightarrow O_3$ is reversible<br><br>**IGNORE** dots<br><br>**IGNORE** other equations involving ozone, eg $O + O_3 \rightarrow 2O_2$<br><br>**IGNORE** comments about an equilibrium<br><br>**ALLOW** rate of forward reaction is similar to the rate of the backward reaction if marking point 1 is awarded |
| | (d) | | $NO + O_3 \rightarrow NO_2 + O_2$ ✓<br><br>$NO_2 + O \rightarrow NO + O_2$ ✓ | 2 | <br><br>**ALLOW** $NO_2 + O_3 \rightarrow NO + 2O_2$ ✓<br><br>**IGNORE** dots<br>**IGNORE** $O + O_3 \rightarrow 2O_2$<br>**IGNORE** $2O_3 \rightarrow 3O_2$ |
| | | | **Total** | **11** | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 6 | (a) | (i) | 256 ✓ | 1 | |
| | | (ii) | $S_8$ ✓ | 1 | **ALLOW** $^{32}S_8$ **OR** $^{32}_{16}S_8$<br>**DO NOT ALLOW** $^{33}S_8$ **OR** $^{30}_{16}S_8$ etc |
| | | (iii) | $S_4^+$ ✓ | 1 | Positive ion must be present<br>**ALLOW** $^{32}S_4^+$ **OR** $^{32}_{16}S_4^+$<br>**DO NOT ALLOW** $^{33}S_4^+$ **OR** $^{30}_{16}S_4^+$ etc |
| | (b) | | **FIRST, CHECK THE ANSWER ON ANSWER LINE**<br>**IF** answer = 195.2, award **2 marks.**<br>**IF** answer = 195.16 award **1 marks.**<br>$= \frac{(194\times33)+(195\times34)+(196\times25)+(198\times8)}{100}$ ✓<br>195.2 ✓ | 2 | 195 on its own with no working scores 0 marks |
| | (c) | | Monitor **air** pollution **OR** breathalysers ✓ | 1 | **ALLOW** measure the concentration or abundance of atmospheric pollutants<br>**ALLOW** measure concentration of named atmospheric pollutant<br>**ALLOW** monitoring of gases in car exhaust fumes<br>**ALLOW** drug detection or drug identification<br>**IGNORE** night vision goggles, identifying gases on distant planets / ice samples |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 6 | (d) | | | 5 | **PLEASE LOOK AT THE SPECTRA AND ABOVE THE SPECTRA FOR POSSIBLE ANSWERS** |
| | | | mole ratio C : H : O<br>$\frac{66.7}{12.0} : \frac{11.1}{1.0} : \frac{22.2}{16.0}$ **OR** 5.56 :11.1 : 1.39 ✓ | | **ALLOW** two marks for<br>72 x 66.7/100 = 48/12 = 4 (C)<br>72 x 11.1/100 = 8 = 8 (H)<br>72 x 22.2/100 = 16 = 1 (O) |
| | | | 4 : 8 : 1 **OR** $C_4H_8O$ ✓ | | |
| | | | contains a C=O or carbonyl because of absorbance at about 1710 $cm^{-1}$ ✓ | | **ALLOW** C=O or carbonyl since has absorbance within the range 1640 to 1750 $cm^{-1}$<br>**ALLOW** ketone **OR** aldehyde linked to correct absorbance<br>**ALLOW** 'could be aldehyde, ketone, carboxylic acid, ester (or amide) because of absorbance between range 1640 to 1750 $cm^{-1}$' (ie direct quote from the data book)<br>**DO NOT ALLOW** reference to **M** being a carboxylic acid, ester or amide **unless** they are included in a list with aldehyde/ketone in which case **IGNORE** carboxylic acid/ester/amide<br>**IGNORE** reference to C—O / absence of O—H<br>**DO NOT ALLOW** has O—H |
| | | | ***Any two from:***<br>  <br>  ✓✓ | | **ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous)<br>**eg** $CH_3CH_2CH_2CHO$, $CH_3COCH_2CH_3$ **OR** $(CH_3)_2CHCHO$<br>**DO NOT ALLOW** $C_3H_7CHO$<br>**IGNORE** incorrect name<br>correct name on its own is **not** sufficient |
| | | | **Total** | **11** | |

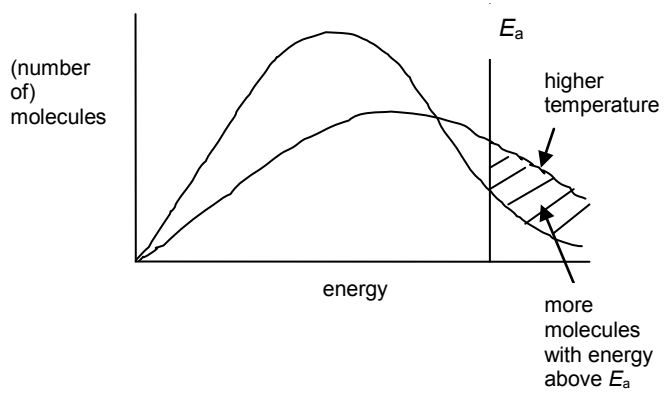
| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 7 | (a) | | **N** ✓ | 1 | **ALLOW** $CF_3CFCl_2$ |
| | (b) | (i) | **S** ✓ | 1 | **ALLOW** $CH_3CHBrCH_2CHICH_3$ |
| | | (ii) | curly arrow from $HO^-$ to carbon atom of C−Br bond ✓<br><br>Dipole shown on C−Br bond, $C^{\delta+}$ and $Br^{\delta-}$, and curly arrow from C−Br bond to the halogen atom – arrow must be very close to the bond ✓<br><br>correct products of the reaction – not ambiguous with the $C_3H_7$ ✓<br><br>  <br><br><br>nucleophilic substitution ✓ | 4 | The curly arrow must start from the **oxygen atom** of the $OH^-$, and must start either from a lone pair or from the negative charge. No need to show lone pair if curly arrow came from negative charge<br>**DO NOT ALLOW** attack by KOH or $K^+OH^-$<br><br>**ALLOW** $S_N1$<br><br>Dipole shown on C−Br bond, $C^{\delta+}$ and $Br^{\delta-}$, and curly arrow from C–Br bond to the halogen atom – arrow must be very close to the bond ✓<br><br>Correct carbocation drawn **AND** curly arrow from $HO^-$ to the carbocation (the curly arrow must start from the **oxygen atom** of the $OH^-$, and must start either from a lone pair or from the negative charge. No need to show lone pair if curly arrow came from negative charge) ✓<br><br>Correct products of the reaction – not ambiguous with the $C_3H_7$ ✓<br><br>nucleophilic substitution ✓ |

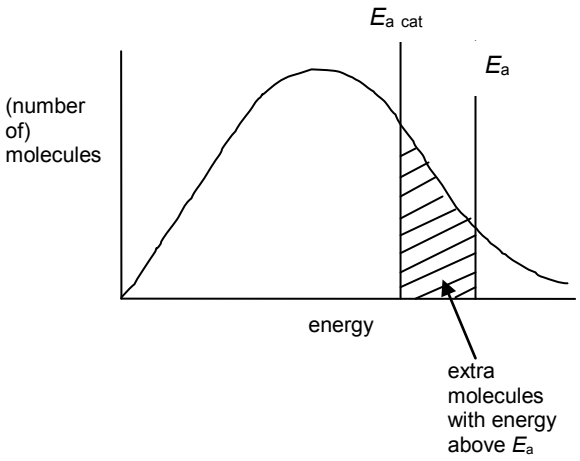
| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 7 | (b) | (iii) | C−I bond is weaker than C−Br bond<br>**OR** C−I has a lower bond enthalpy than C−Br bond<br>**OR** C−I bond is longer than C−Br bond<br><br>**AND**<br><br>C−I bond is easier to break than C−Br bond<br>**OR** less energy is needed to break the C−I bond ✓ | 1 | Answer must refer to the correct bond<br><br>**ALLOW** ora<br><br>**IGNORE** references to electronegativity |
| | (c) | | HC*l* + $CH_3CHCHCH_3$ → $CH_3CH_2CHC/CH_3$<br><br>Correct structural formula of product ✓<br><br>Equation with structural formulae ✓ | 2 | Must use **structural formulae** for both organic compounds in the equation<br><br>**ALLOW** $CH_3CH{=}CHCH_3$ for but-2-ene<br><br>**ALLOW** two marks for correct equation with structural formulae<br><br>**ALLOW** one mark for correct equation with displayed formulae<br><br>**IGNORE** any mechanisms |
| | (d) | | HCFCs **OR** hydrocarbons **OR** HFCs ✓ | 1 | **ALLOW** alkanes<br>**DO NOT ALLOW** specific alkanes |
| | | | **Total** | **10** | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 8 | (a) | |  ✓ | 1 | **ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous)<br><br>**ALLOW** two or more repeat units but has to be a whole number of repeat units<br><br>**ALLOW** vertical bond to CN to any part of the CN<br><br>End bonds **MUST** be shown as either dotted or normal line<br><br>**IGNORE** brackets<br>**IGNORE** *n* |
| | (b) | | All the reactants are made into the desired product<br>**OR**<br>it is an addition reaction ✓ | 1 | **ALLOW** there are no waste (products) **OR** there are no by-products **OR** only one product is made<br>**ALLOW** an addition polymer is made<br>**DO NOT ALLOW** all the product**s** are useful<br>**IGNORE** additional reaction |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 8 | (c) | | **QWC – Linking effect with explanation** | 5 | |
| | | | (as temperature rises) position of equilibrium changes to **minimise effect** of temperature rise by **absorbing energy** **OR** (as pressure rises) position of equilibrium changes to **minimise** the pressure increase by **reducing the pressure** and making fewer gas molecules ✓ | | |
| | | | as temperature rises the position of equilibrium shifts to the left **AND** increase in pressure shifts the equilibrium to the left ✓ | | **ALLOW** suitable alternatives for 'to the left' eg moves to the reactant side **OR** towards $C_3H_6(g)$ or $NH_3(g)$ or $O_2$ **OR** moves in reverse direction<br>**IGNORE** responses in terms of rate |
| | | | relates change with temperature to the (forward) reaction being exothermic **OR** reaction releases energy or heat<br>**OR**<br>**reverse** reaction is endothermic **OR reverse** reaction takes in heat or energy ✓ | | This mark is dependent on correct change in position of equilibrium<br><br>Moves towards the endothermic direction is **not** sufficient |
| | | | change with pressure because there are fewer moles of reactants **OR** more moles of products ✓ | | **ALLOW** fewer molecules of reactant<br>This mark is dependent on correct change in position of equilibrium |
| | | | removing the catalyst does not change the position of equilibrium ✓ | | **ALLOW** equilibrium does not move **OR** catalyst has no effect on the equilibrium |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 8 | (d) | | **FIRST, CHECK THE ANSWER ON ANSWER LINE**<br>**IF** answer = 95.5, award **2 marks.**<br><br>actual amount propenenitrile is 210 (mol) ✓<br><br><br><br>% yield = 95.454545 ✓ | 2 | **IF** there is an alternative answer, check to see if there is any **ECF** credit possible using working below<br><br>**ALLOW** theoretical mass of propenenitrile = 11660 g **OR** 11.66 kg<br>**ALLOW** 11700 **OR** 11.7kg<br><br>**ALLOW** 95 up to calculator value of 95.454545 correctly rounded up<br><br>**ALLOW** 95 up to calculator value of 95.128205 correctly rounded up if 11.7kg is used'<br><br>**ALLOW** ecf from wrong actual mass or actual amount<br><br>**DO NOT ALLOW** ecf if percentage yield is above 100% |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| (e) | ***Boltzmann distribution*** | 7 | |
| | Correct drawing of one Boltzmann distribution (could be temperature or catalyst) ✓ | | Look at the first Boltzmann distribution on the paper:<br>If it is the temperature one then both curves will have to be correct<br><br>Boltzmann distribution – must start at origin and must not end up at 0 on y-axis ie must not touch x-axis<br><br>**ALLOW** a slight inflexion in the Boltzmann curve |
| | axes labelled (number of) molecules and energy ✓ | | **ALLOW** particles instead of molecules<br>**DO NOT ALLOW** atoms instead of particles or molecules<br>**DO NOT ALLOW** number of particles at activation energy<br>**DO NOT ALLOW** enthalpy<br>**ONLY** penalise the incorrect use of atoms (instead of molecules or particles) the first time it is seen |
| | ***Increasing the temperature***<br><br>Correct drawing of Boltzmann distribution at **two** different temperatures with higher and lower temperature clearly identified ✓<br><br>  <br> | | Maximum of curve for higher temperature to right<br>**AND** lower than maximum of lower temperature curve<br>**AND** above lower temp line at higher energy as shown in diagram below<br>Higher temperature line should intersect the lower temperature only once |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| | | | ***Adding a catalyst***<br>  <br><br>idea that activation energy is lowered with a catalyst ✓ | | **ALLOW** $E_c$ **OR** $E_{cat}$ for activation energy of catalysed reaction<br>**ALLOW** activation lowered shown on Boltzmann distribution diagram |
| | | | ***Collision theory***<br>reaction is faster with catalyst **AND** when temperature is increased ✓<br>Greater proportion of molecules with energy above activation energy (with increased temperature or when catalyst is used ) ✓<br>more effective collisions **OR** more successful collisions (with increased temperature or when catalyst is used) ✓ | | **ALLOW** more molecules with energy above activation energy **OR** more molecules that overcome the activation energy **OR** more molecules have enough energy to react<br>**ALLOW** this marking point **once** either in terms of using a catalyst or increasing the temperature<br>**ALLOW** this marking point **once** either in terms of using a catalyst or increasing the temperature<br>**ALLOW** more collisions involving particles with energy above the activation energy<br>More collisions per second is **not** sufficient |
| | | | **Total** | **16** | |

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