OCR
Oxford Cambridge and RSA

GCE

Chemistry A

Unit **H032/02:** Depth in chemistry

Advanced Subsidiary GCE

Mark Scheme for June 2018

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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.

Annotations

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
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
AW	Alternative wording
ORA	Or reverse argument
	Correct response
	Incorrect response
	Omission mark
BOD	Benefit of doubt given
CON	Contradiction
RE	Rounding error

SF	Error in number of significant figures
ECF	Error carried forward
L1	Level 1
L2	Level 2
L3	Level 3
NBOD	Benefit of doubt not given
SEEN	Noted but no credit given
I	Ignore

Subject-specific Marking Instructions

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>1</td><td>(a)</td><td></td><td>A solution of known concentration ✓</td><td>1</td><td>ALLOW description of concentration</td></tr>
<tr><td>1</td><td>(b)</td><td></td><td>Releases OH$^-$ (ions in aqueous solution) ✓</td><td>1</td><td>ALLOW containing OH$^-$ ions
IGNORE mention of pH</td></tr>
<tr><td>1</td><td>(c)</td><td>(i)</td><td>
<table>
<tr><td>Final reading/cm^3</td><td>27.30</td><td>27.00</td><td>27.75</td></tr>
<tr><td>Initial reading/cm^3</td><td>0.45</td><td>0.60</td><td>1.25</td></tr>
<tr><td>Titre/cm^3</td><td>26.85</td><td>26.40</td><td>26.50</td></tr>
</table>
Initial and final readings
All burette readings (×6) correct ✓

Titres recorded to two decimal places with the last figure either 0 or 5
Correct subtractions to obtain final titre values ✓

Mean titre calculated from concordant results
Correct mean titre = 26.45 (cm^3) ✓

Mean titre recorded to accuracy of burette
Final answer recorded to two decimal places with the last figure either 0 or 5 ✓
</td><td>4</td><td>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC

ALLOW missing zeroes for burette readings
i.e. 0.6 for 0.60
27 OR 27.0 for 27.00

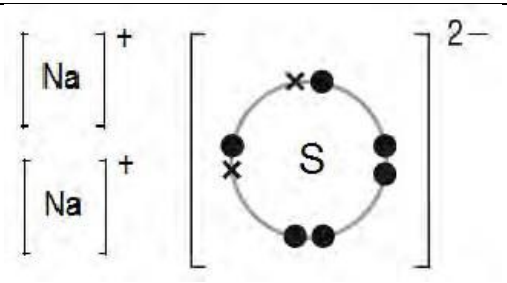
ALLOW ECF from incorrect burette readings

IF MEAN IS CALCULATED FROM ECF, IT MUST BE FROM CLOSEST TITRES

ALLOW ecf from incorrect mean
DO NOT ALLOW 26.5 cm^3
Question asks for nearest 0.05 cm^3</td></tr>
<tr><td>1</td><td>(c)</td><td>(ii)</td><td>$\frac{2 \times 0.05}{26.85} \times 100 = 0.37(2)$ (%) ✓</td><td>1</td><td>ALLOW 0.4 up to full calculation display of 0.372439478
ALLOW ECF FOR CORRECT CALCULATION FROM 1 (c) (i) OR USE OF ANY TITRE</td></tr>
</table>

Question			Answer	Marks	Guidance
1	(c)	(iii)	Use a (250 cm^3) **volumetric** flask (instead of a beaker) ✓	1	**IGNORE** graduated flask
1	(d)	(i)	**FIRST CHECK ANSWER ON ANSWER LINE** If answer = 118 (g mol^{-1}) award 4 marks If answer = 108 (g mol^{-1}) award 3 marks --- *n*(NaOH) $= 0.112 \times \frac{25.0}{1000} = 0.00280$ (mol) ✓ *n*(**A**) in 25.0 cm^3 $= \frac{0.00280}{2} = 0.00140$ (mol) ✓ *n*(**A**) in 250 cm^3 $= 0.00140 \times \frac{250.0}{27.30} = 0.0128$ (mol) ✓ Molar mass, *M*(**A**) to nearest whole number. $= \frac{1.513}{0.0128} = 118$ (g mol^{-1}) ✓	4	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC** Throughout: **IGNORE** trailing zeroes in intermediate working, e.g. For *n*(NaOH) **ALLOW** 0.0028 for 0.00280 **ALLOW ECF** from incorrect *n*(NaOH) **ALLOW ECF** from incorrect *n*(A) **OR** *n*(NaOH) **ALLOW** 3 sig fig up to full calculator display correctly rounded (0.012820512) **ALLOW ECF** from incorrect *n*(NaOH) --- **Possible ECFs for 3 marks** 1.513 ÷ (0.00140 × 250/25) = **108** 1.513 ÷ 0.00140 = **1081** No ÷2 for n(**A**) • Molar mass **A** = 59 (g mol^{-1}) Using mean titre of 26.45 cm^3 from **1c(i)** • Molar mass **A** = 114 (g mol^{-1}) Using 27.3 × 0.112 in M1 and then 25.0 in M3 • Molar mass **A** = 99 (g mol^{-1})

Question			Answer	Marks	Guidance
1	(d)	(ii)	Structure of dicarboxylic acid $HOOCCH_2CH_2COOH$ **OR** $HOOCCH(CH_3)COOH$ ✓ **STRUCTURE MUST MATCH** M_r from answer to 1 d) i) (within 10 AMU)	1	**ALLOW** correct structural **OR** skeletal **OR** displayed formulae **OR** a combination **ALLOW** incorrect connectivity e.g –HO **ALLOW ECF** from incorrect molar mass in **(d)(i)** but only if 2 × COOH possible and M_r is a close match to **(d) (i) within 10 AMU**
			Total	**13**	

Question			Answer	Marks	Guidance
2	(a)		 Na shown with either 0 or 8 electrons **AND** S shown with 8 electrons with 6 dots and 2 crosses (or vice versa) ✓ Correct charges ✓	**2**	**ALLOW** $2[Na]^+$ **ALLOW** $[Na]^+_2$ Brackets not required **For first mark**, if eight electrons are shown around Na, the 'extra' electrons around S must match the symbol chosen for the electrons for Na. **IGNORE** inner shells Circles **not** required
2	(b)			**3**	Mark by **COLUMN**

	Na_2S	**Na**	**S**
Melting point / °C	1180	98	113
Type of structure	**giant**	**giant**	**simple**
Conductivity of solid	**poor**	**good**	**poor**
Conductivity of liquid	**good**	**good**	**poor**
	✓	✓	✓

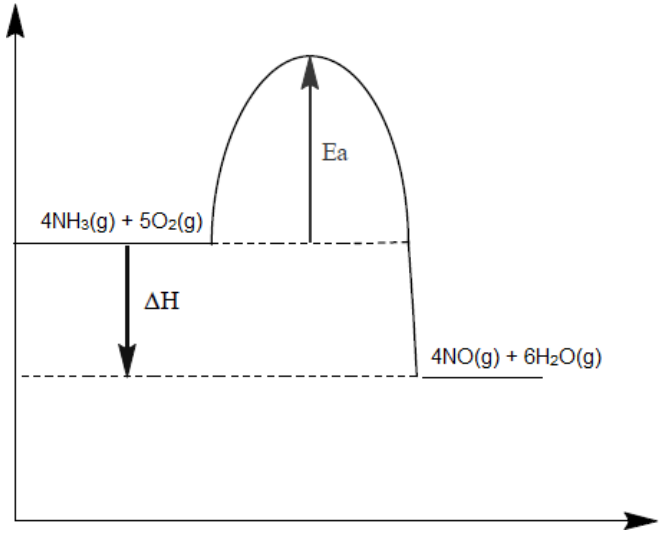
One mark for **each correct column**

Question			Answer	Marks	Guidance
2	(c)	(i)	$(1s^2)\ 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^4$ ✓ Look carefully at $(1s^2)\ 2s^2 2p^6 3s^2 3p^6$ – there may be a mistake	1	**ALLOW** subscripts **ALLOW** in any order i.e. $3d^{10}$ after $4s^2$ or after $4p^4$ **ALLOW** upper case D, etc and subscripts, e.g .....$3S_2 3P^6$ **DO NOT ALLOW** [Ar] as shorthand for $1s^2 2s^2 2p^6 3s^2 3p^6$
2	(c)	(ii)	**Gas B** H_2Se / Hydrogen selenide / Selenium hydride ✓ **Equation** $Na_2Se + 2HCl \rightarrow 2NaCl + H_2Se$ All formulae and balancing ✓	2	**ALLOW** SeH_2 **ALLOW** correct multiples **IGNORE STATE SYMBOLS** **DO NOT ALLOW** H_2S for gas B **BUT ALLOW ECF** from H_2S for equation: $Na_2S + 2HCl \rightarrow 2NaCl + H_2S$
			Total	8	

Question			Answer	Marks	Guidance
3	(a)	(i)	$Br_2 + 2I^- \rightarrow I_2 + 2Br^-$ ✓	1	**ALLOW** multiples **IGNORE** state symbols
		(ii)	Iodine has a larger atomic radius ✓ Iodine has greater shielding / more shells ✓ Iodine has weaker / less **nuclear** attraction (on electron gained than bromine) ✓	3	**ORA** **ALLOW** iodine is larger / bromine is smaller **ALLOW** electron added to a shell further from the nucleus **ALLOW** bromine has greater **nuclear** attraction **IGNORE** 'gained less easily' for 'weaker attraction' **IGNORE** references to ionisation energy **DO NOT ALLOW** mention of losing electrons for M3 **ALLOW** 'pull' for 'attraction' **IGNORE** just 'greater attraction' **OR** greater force

Question			Answer	Marks	Guidance
3	(b)	(i)	**Disproportionation** Oxidation **AND** reduction of same element/iodine **OR** Iodine has been **oxidised** and Iodine has been **reduced** ✓ **Oxidation** from **0** to **+1** in **HIO** ✓ **Reduction** from **0** to **–1** in **HI** ✓	**3**	**ALLOW** I or I_2 for iodine **IGNORE** numbers around equation for oxidation states **ALLOW** 1– for –1 **AND** 1+ for +1 **NOTE** (for iodine/I_2) **from 0** only needs to be seen once, does not need to be stated twice **ALLOW** 1 mark for 3 ox nos correct but no mention of words **oxidation/reduction**: 0 in I_2 **AND** –1 in HI **AND** +1 in HIO **ALLOW** 1 mark for species missing: Iodine oxidised (from 0) to +1 **AND** iodine reduced (from 0) to –1
3		(ii)	Chlorine is toxic/poisonous **OR** forms halogenated hydrocarbons **OR** forms carcinogens/toxic compounds ✓	**1**	**ALLOW (**reacts with hydrocarbons to) form carcinogens/toxic compounds **IGNORE** • chlorine causes cancer • harmful/dangerous • chlorine causes breathing problems
3	(c)		**FIRST CHECK ON ANSWER LINE** **If answer = (+) 431.5 (kJ mol^{-1}) award 2 marks** **If answer = –431.5 (kJ mol^{-1}) award 1 mark** (wrong sign) --- **2 × H–C*l* bond enthalpy correctly calculated** = +436 +243 +184 = +863 (kJ mol^{-1}) ✓ **H–C*l* bond enthalpy correctly calculated**	**2**	**ALLOW** to **3 SF** i.e. 432

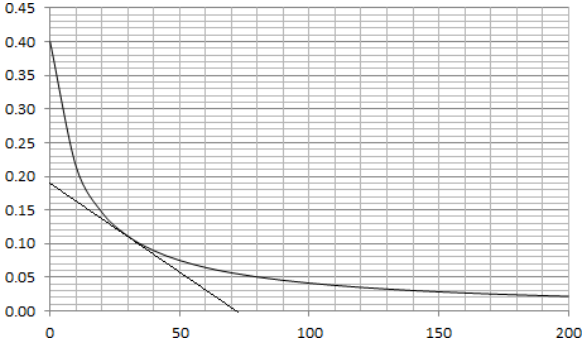
Question			Answer	Marks	Guidance
			+863/2 = (+)431.5 (kJ mol^{-1}) ✓		**ALLOW** 1 mark for (+)247.5 / 248 (wrong expression) i.e. (436+243–184)/2
	(d)	**(i)**	$Br_2(l) \rightarrow Br_2(g)$ ✓	**1**	
		(ii)	Endothermic **AND** Energy required to overcome induced dipole–dipole forces/London forces ✓	**1**	**Mark independently of 3 (d) (i)** **ALLOW** endo to break **intermolecular** forces/bonds **ALLOW** bonds between molecules **DO NOT ALLOW** van der Waals' forces
			Total	**12**	

Question			Answer	Marks	Guidance
4	(a)	(i)	 **Reactants, products and E_a** Reactants on LHS **$4NH_{3(g)} + 5O_{2(g)}$** **AND** Products on RHS **$4NO_{(g)} + 6H_2O_{(g)}$** **AND** Activation energy correctly labelled / E_a ✓ ***ΔH*** *ΔH* labelled with product below reactant **AND** Arrow downwards ✓	2	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC** **IGNORE** state symbols ALLOW 1 mark for a correctly labelled endothermic diagram ***E_a*** **ALLOW** no arrowhead or arrowheads at both end of E_a line. E_a line must reach maximum (or near to maximum) on curve For E_a, **ALLOW** AE **OR** A_E ***ΔH*** **DO NOT ALLOW –*ΔH*** **DO NOT ALLOW** double headed arrow on *ΔH* **ALLOW** *ΔH* arrow even with small gap at the top and bottom, i.e. line does not quite reach reactant or product line. **ALLOW** –905 for *ΔH*

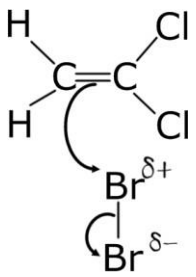
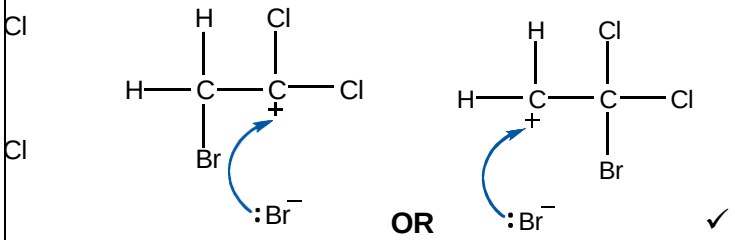
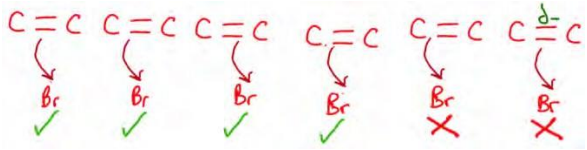
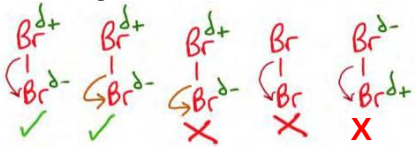
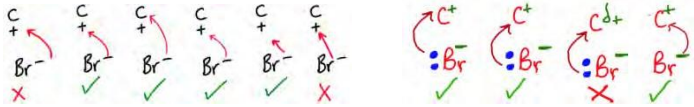
Question			Answer	Marks	Guidance
		(ii)	**FIRST CHECK ON ANSWER LINE** **If answer = 6.79 × 10^7 (kJ) award 4 marks** **If answer = 2.72 × 10^8 (kJ) award 3 marks** (no ÷ 4) --- ***n*(NH$_3$)** = $\frac{5.1 \times 10^6}{17}$ = 3.00 × 10^5 (mol) ✓ **Stoichiometry and Δ*H*** 1 mol NH$_3$ releases $\frac{905}{4}$ **OR** 226.25 (kJ) ✓ **Energy released** (3.00 × 10^5) × $\frac{905}{4}$ **OR** 67875000 (kJ) ✓ **Final answer to 3SF AND standard form** = 6.79 × 10^7 (kJ) ✓ *standard form* **AND** *3 SF required*	**4**	**IGNORE** (-) SIGN Throughout: **IGNORE** trailing zeroes in intermediate working, e.g. For *n*(NH$_3$) **ALLOW** 3 × 10^5 for 3.00 × 10^5 --- **ALLOW ECF** from incorrect *n*(NH$_3$) **OR** 905/4 **ALLOW 3 SF** up to calc value correctly rounded. Value will depend on intermediate rounding **Common Errors** 1.09 × 10^9 (x 4 instead of ÷ 4) 3 marks 2.72 × 10^8 (no ÷ 4) 3 marks 6.79 × 10^1 (no tonnes → g) 3 marks
	(b)		$(K_c =)$ $\frac{[NO(g)]^4\,[H_2O(g)]^6}{[NH_3(g)]^4\,[O_2(g)]^5}$ ✓	**1**	Square brackets required **IGNORE** state symbols

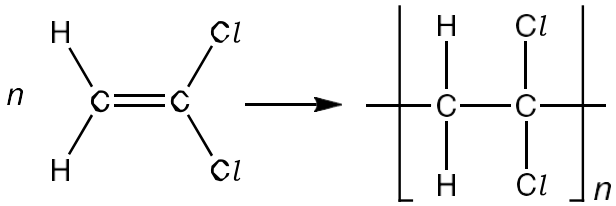
Question			Answer	Marks	Guidance
4	(c)		***EQUILIBRIUM CONDITIONS*** **Temperature: 1 mark** (Forward) reaction is exothermic/Δ*H* is negative **OR** (Forward) reaction gives out heat ✓ **Pressure: 1 mark** Left-hand side has fewer (gaseous) moles **OR** 9 (gaseous) moles form 10 (gaseous) moles ✓ ***OPTIMUM EQUILIBRIUM CONDITIONS:* 1 mark** (for maximum yield of NO) Low temperature **AND** low pressure ✓ ***RATE:* 1 mark** Low temperature/pressure gives a slow rate/slower reaction so high temperatures / higher pressure needed to increase **rate OR frequency of collisions** ✓ ***INDUSTRIAL CONDITIONS* / OPERATIONAL FACTORS: 1 mark** High pressure provides a safety risk **OR** Higher temperatures increase energy costs / reduce yield / shift equilibrium to left **OR** (High) pressure is expensive (to generate) / uses a lot of energy ✓	**5**	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC** **ALLOW reverse arguments** Answer **MUST** relate temp/pressure to rate / frequency of collisions **ALLOW** Temperature / pressure not too high because yield reduced **IGNORE** stated temperatures and pressures **IGNORE** catalyst
			Total	**12**	

Question			Answer	Marks	Guidance
5	(a)	(i)*	*Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Correctly labelled diagram of reflux apparatus that works, with no safety problems **AND** An appreciation of most of the purification steps required to gain a pure sample *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Labelled diagram of apparatus (either reflux or distillation) but with safety/procedural problems **OR** clear diagram of reflux apparatus without labelling **AND** Some details of further purification steps *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** Diagram of apparatus (**reflux OR separation OR distillation**) drawn with no labelling **OR** labelled diagram with significant safety/procedural **AND / OR** Few or imprecise details about further purification stages *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** No response or no response worthy of credit.	**6**	**Indicative scientific points may include:** **Apparatus set up for reflux:** • round-bottom/pear shaped flask • heat source • condenser *Detail: water flow in condenser bottom to top; open system.* **Purification** • Use of a **separating funnel** to separate organic and aqueous layers *Detail: Collect lower organic layer density greater* • **Drying** with an anhydrous salt, *Detail: e.g. $MgSO_4$, $CaCl_2$, etc.* • **Redistillation** *Detail: Collect fraction distilling at 102ºC.*

Question			Answer	Marks	Guidance
5	(a)	(ii)	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF answer = 12.6 (g) award 2 marks** • n(1-bromobutane) = $0.150 \times \frac{61.4}{100}$ = 0.0921 (mol) ✓ • Mass 1-bromobutane = 0.0921 × 136.9 = 12.6 (g) ✓ **3 SF required**	2	**Common errors:** **33.4** (0.150 x 100/61.4 = 0.244 x 136.9) 1 mark **ALLOW ECF** for incorrect moles or incorrect M_r **of 1-bromobutane** (provided answer is to 3 SF) **DO NOT ALLOW** 6.82 (using M_r of butan-1-ol) **ALLOW** calculation using masses, e.g. • Theoretical = 0.150 × 136.9 = 20.535 (g) ✓ *(**ALLOW** 20.535 rounded back to 20.5)* • Actual mass = $20.535 \times \frac{61.4}{100}$ = 12.6 (g) ✓ *(20.5 also gives 12.6)*
	(b)		**Tangent on graph** drawn at approximately t = 30 min (±10 mins) ✓ **Calculation of rate** = Gradient (y/x) of tangent drawn e.g. $\frac{0.19}{72}$ = 2.64×10^{-3} / 0.00264 (mol $dm^{-3}min^{-1}$)✓  	2	**DO NOT ALLOW** interpolation (taking a direct reading from graph), answer must be derived from taking a gradient **ALLOW ecf from incorrectly drawn tangent** **Tolerance:** Readings from y axis should be ± 0.01 mol dm^{-3} (i.e. within 1 square) Readings from x axis should be ± 5 minutes (i.e. within 0.5 of a square) **IGNORE** units **IGNORE** sign
			Total	**10**	

Question			Answer	Marks	
6	(a)		steam **AND** Acid/H^+ (catalyst) ✓	1	
	(b)	(i)	1,2-dibromo-1,1-dichloroethane ✓	1	

Question			Answer	Marks	Guidance
6	(b)	(ii)	 **1st curly arrow (from ANY alkene)** Curly arrow from double bond to Br of Br–Br ✓ **DO NOT ALLOW** partial charge on C=C **2nd curly arrow** Correct dipole on Br–Br **AND** curly arrow for breaking of Br–Br bond ✓ **3rd curly arrow** **Correct carbocation** with + charge on C with 3 bonds **AND** curly arrow from Br^- to C^+ of carbocation ✓ **DO NOT ALLOW** δ+ on C of carbocation  *i.e. ALLOW carbonium + on either C atom* **DO NOT ALLOW** half headed or double headed arrows but allow **ECF** if seen more than once	3	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC** **For curly arrows, ALLOW straight or snake-like arrows and small gaps (see examples):** **1st curly arrow** must • go to a Br atom of Br–Br **AND** • start from, **OR** be traced back to **any point across width** of C=C  **2nd curly arrow** must • start from, **OR** be traced back to, **any part of** $^{\delta+}$Br–Br$^{\delta-}$ bond • **AND** go to Br $^{\delta-}$  **3rd curly arrow** must • go to the C^+ of carbocation **AND** • start from, **OR** be traced back to **any point across width** of lone pair on :Br^- • **OR** start from – charge on Br^- ion  *(Lone pair **NOT** needed if curly arrow shown from – charge on Br^-)*

Question			Answer	Marks	Guidance
6	(c)	(i)	 Correct polymer with side links and brackets ✓ Equation balanced with *n* ✓ **TAKE CARE** of '*n*' position on both sides of equation.	2	**For repeat unit,** • displayed formula required • 'side bonds' required on either side of repeat unit from C atoms • **ALLOW** section containing more than one repeat unit **DO NOT ALLOW ECF** from incorrect repeat unit *n* on LHS at any height to the left of the formula *n* on RHS must be subscript
	(c)	(ii)	**Advantage (1 mark)** Energy production / (energy) used to produce electricity ✓ **Disadvantage (1 mark)** Formation of HCl/products of combustion cause acid rain **OR** Formation of CO_2/gases that cause global warming / greenhouse gases **OR** Formation of CO✓	2	**ALLOW** reduced use of fossil fuels **ALLOW** less landfill / less harm to wildlife **ALLOW** chlorine/Cl **OR** Cl_2 **ALLOW** toxic/poisonous waste products
			Total	9	

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>7*</td><td>Please refer to the marking instructions on page 5 of the mark scheme for guidance on how to mark this question.

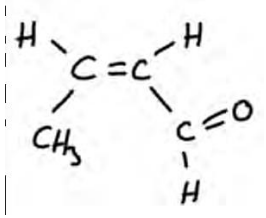
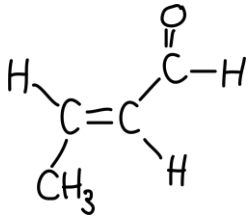
Level 3 (5-6 marks)
A comprehensive description including most of the evidence to justify the correct structure of F (accept cis or trans).
There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)
The candidate attempts all three scientific points, but explanations are incomplete.
OR
Explains two scientific points thoroughly with few omissions.
AND
an attempt at a feasible structure based on deduction from correct molecular formula
There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.

Level 1 (1–2 marks)
The correct empirical formula
AND a simple description based on at least one of the main scientific points.
OR
The candidate explains one scientific point thoroughly with few omissions.
There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks No response or no response worthy of credit.</td><td>6</td><td>LOOK AT THE SPECTRA for labelled peaks
Indicative scientific points may include:

<u>Empirical formula</u>
• empirical formula = C_4H_6O
<table><tr><th>element</th><th>% mass</th><th>Ar</th><th>moles</th><th>ratio</th></tr><tr><td>C</td><td>68.6</td><td>12</td><td>5.72</td><td>4</td></tr><tr><td>H</td><td>8.6</td><td>1</td><td>8.60</td><td>6</td></tr><tr><td>O</td><td>22.8</td><td>16</td><td>1.43</td><td>1</td></tr></table><u>IR and spectra and molecular formula</u>
• infrared absorption; 1630–1820 cm^{-1}, due to C=O (aldehyde/ketone/carbonyl group)
• molar mass = 70 g mol^{-1}
(mass spectrum molecular ion peak m/z = 70)
• molecular formula = C_4H_6O

<u>Functional groups, structure and stereochemistry</u>
• alkene / C=C
• aldehyde / –CHO ($C_3H_5^+$ fragment)
• mass spectrum; peak at 41 due to $C_3H_5^+$ (loss of CHO)
• E/Z or cis-trans isomer: E/Z or cis-trans isomer:
 
 
cis trans (correct structure)</td></tr>
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