OCR
Oxford Cambridge and RSA

GCE

Chemistry A

Unit **H432/03:** Unified chemistry

Advanced 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 available in RM Assessor

Annotation	Meaning
	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
BP	Blank page

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
BOLD	Emboldened words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

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.

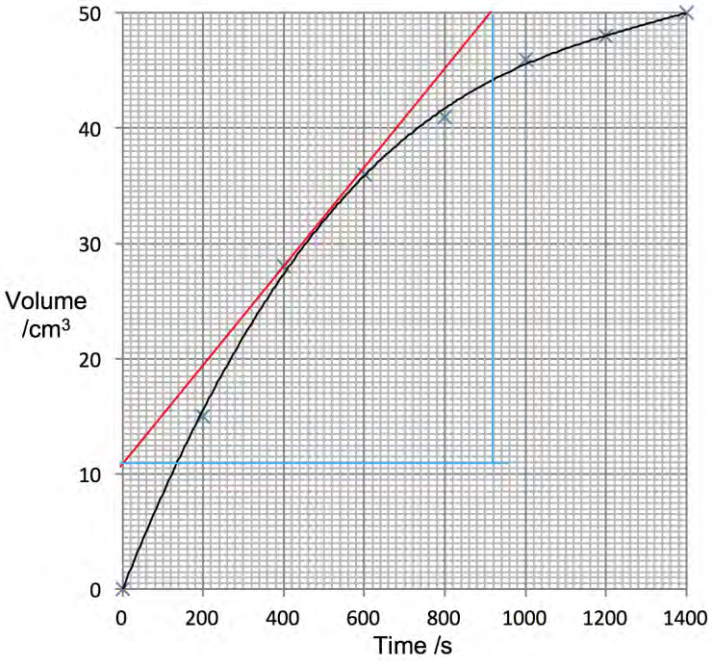
You should ensure that you have copies of these materials.

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.

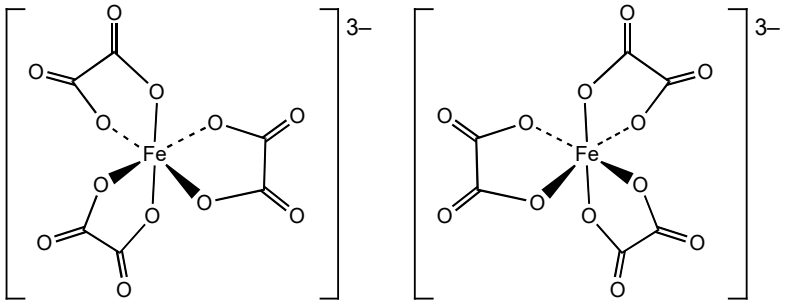
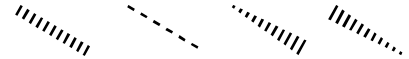
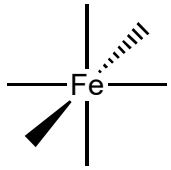
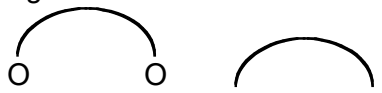
Question			Answer	Marks	Guidance
1	(a)	(i)	Hydrogen/H ✓	1	**ALLOW** H_2
		(ii)	Helium/He ✓	1	
		(iii)	Magnesium/Mg ✓	1	
		(iv)	Sulfur/S ✓	1	**ALLOW** sulphur; S_8
		(v)	Chlorine/C*l* **OR** fluorine/F ✓	1	**ALLOW** Cl_2 OR F_2
		(vi)	Phosphorus/P ✓	1	**ALLOW** P_4
		(vii)	Carbon/C ✓	1	**ALLOW** silicon/Si
		(viii)	Oxygen/O ✓	1	**ALLOW** O_2

Question	Answer	Marks	Guidance
(b)	**NaC*l* OR MgCl_2** **2 marks** Giant **ionic OR ionic** lattice ✓ **Ions** are **mobile** in **liquid** state ✓ --- **SiCl_4 OR PCl_3 OR SCl_2** **2 marks** (Simple) molecular **OR** simple covalent (lattice) ✓ Induced dipole(–dipole) forces/interactions **OR** London forces ✓ --- **Comparison of bond strengths** **1 mark** • Ionic bonds are stronger than London forces **OR** • Ionic bonds need more energy to break than London forces ✓	5	**IGNORE** aqueous/dissolved ions are mobile **IGNORE** 'free ions' **AND** 'ions are free to carry current' --- **ALLOW** 'are molecules' **IGNORE** • permanent dipole(–dipole) forces • IDID and LDF • van der Waals --- **ALLOW** attraction between ions for ionic bonds **ALLOW** intermolecular forces for London forces **ALLOW** overcome for break **ALLOW** indirect comparison, i.e. • Ionic bonds are strong **AND** London forces are weak **OR** • Ionic bonds need a large amount of energy to break **AND** London forces need little energy to break
	Total	13	

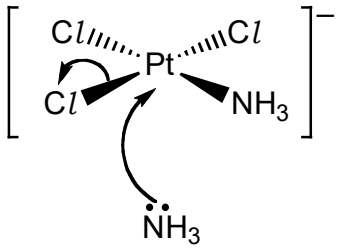
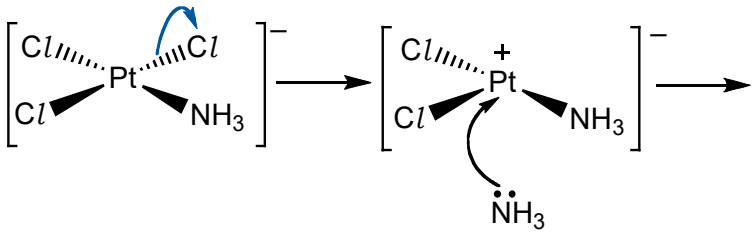
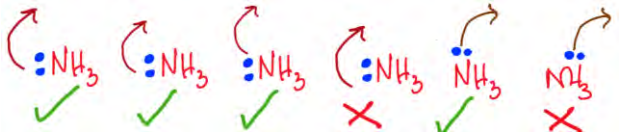
Question			Answer	Marks	Guidance
2	(a)		**Graph** Graph of volume (y axis) against time (x axis) **AND** Axes labelled with correct units **AND** At least half graph paper in both directions **AND** Linear scales ✓ **Points** 7 points from 200–1400 s plotted ✓ *Point at 0,0 not required* **Line** **Curve** drawn through origin (0,0) ✓ **AND** **Curve** not drawn with straight lines between points. **Rate** Attempted tangent on graph drawn to curve at t = 500 ± 100 s ✓ Rate calculated in range 0.037–0.047 ($cm^3\ s^{-1}$) ✓ *e.g. for graph in guidance:* $\frac{50-11}{920-0} = 0.042$ --- **For tangents not drawn at 500 ± 100 s,** • **ALLOW ECF ONLY** for a tangent drawn to the candidate's line. • Then calculate the gradient from candidate's tangent. **For inverse graphs of time against volume,** • Graph mark will **not** be scored. • All other marks are available. • **BUT** rate = 1/ gradient = 0.037–0.047 ($cm^3\ s^{-1}$)	5	 **ALLOW** *V* **OR** Vol for volume **ALLOW** *t* for time For 's', **ALLOW** sec, seconds, etc **CARE:** Use of *x* and *y* coordinates at t = 500 s scores zero, e.g. For volume = 33 cm^3 and time = 500 s, *x* and *y* coordinates gives 33/500 = 0.066 ✗✗

Question			Answer	Marks	Guidance
		(ii)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 0.092 (mol dm^{-3}) award 3 marks** --- $n(O_2) = \frac{55}{24000} = 2.29 \times 10^{-3}$ (mol) ✓ $n(H_2O_2) = 2.29 \times 10^{-3} \times 2 = 4.58 \times 10^{-3}$ (mol) ✓ $[H_2O_2] = \frac{4.58 \times 10^{-3} \times 1000}{50.0} = 0.092$ (mol dm^{-3}) ✓ (**2 SF**)	**3**	**ALLOW ECF** throughout **ALLOW** 2 SF up to calculator value of 2.291666667 $\times 10^{-3}$ **ALLOW** calculation using ideal gas equation provided that p = ~ 10^5 Pa and T in range 293–298 K. **ALLOW** use of 8.31 for R (gives same answer) **e.g.** $n(O_2) = \frac{1 \times 10^5 \times 55 \times 10^{-6}}{8.314 \times 298} = 2.22 \times 10^{-3}$ (mol) ✓ $n(H_2O_2) = 2.22 \times 10^{-3} \times 2 = 4.44 \times 10^{-3}$ (mol) ✓ $[H_2O_2] = \frac{4.44 \times 10^{-3} \times 1000}{50.0} = 0.089$ (mol dm^{-3}) ✓ (2 SF) **NOTE**: 293 K gives 0.090 (mol dm^{-3}) **Common errors** 0.046 → 2 marks no × 2 for $n(H_2O_2)$
	(b)		$2MnO_4^- + 5H_2O_2 + 6H^+ \rightarrow 2Mn^{2+} + 8H_2O + 5O_2$ Correctly balanced equation for MnO_4^-/H_2O_2 reaction but no cancelling of H^+ and/or e^- ✓ Overall equation correct with all species cancelled ✓	**2**	**ALLOW** multiples **ALLOW** ⇌ instead of → sign **ALLOW** 1 mark for final equation with correct balancing numbers **AND** **ONE** small slip in a formula **OR** charge **IGNORE** annotations around equations, i.e. treat as rough working **ALLOW** 1 mark for: $2H_2O_2 \rightarrow 2H_2O + O_2$ *(H_2O_2 is acting as both reducing and oxidising agent)*

Question			Answer	Marks	Guidance
	(c)	(i)	**Equation** $[Co(H_2O)_6]^{2+} + 4Cl^- \rightleftharpoons [CoCl_4]^{2-} + 6H_2O$ **OR** $[Co(H_2O)_6]^{2+} + 4HCl \rightleftharpoons [CoCl_4]^{2-} + 6H_2O + 4H^+$ ✓	1	**ALLOW** reverse equation: $[CoCl_4]^{2-} + 6H_2O \rightleftharpoons [Co(H_2O)_6]^{2+} + 4Cl^-$ but take care for subsequent explanations **IGNORE** state symbols (even if wrong) For $[CoCl_4]^{2-}$, **ALLOW** $CoCl_4^{2-}$, $(CoCl_4)^{2-}$ For other representations, contact TL
		(ii)	**Equilibrium shift** • equilibrium (shifts) **to right** at high **temperature**/100ºC **OR** equilibrium shifts to left at low temperature/0ºC ✓ **CARE: Direction of shift** depends on direction of equilibrium equation from 2c(i). Either look back or see the equation copied at bottom of 2c(ii) marking zone. --- **Enthalpy change** • Endothermic ✓	2	**Mark independently** **ALLOW** suitable alternatives for 'to right' e.g. towards products **OR** in forward direction **OR** 'favours the right' **ORA** for 'to left' **Temperature** required but **ALLOW** 'in ice for low temperature **OR** 'in boiling/hot water' for high temperature **IGNORE** shift to blue side or pink side ---
			Total	13	

Question			Answer	Marks	Guidance
3	(a)		Overall 3– charge shown (outside brackets) for at least **ONE** isomer ✓ *3– must apply to the overall charge of structures*  1 mark for each isomer ✓✓ • *Bonds **must** go to O ligand atoms on **EACH** structure* • ***ALLOW** unambiguous structures; ethanedioate ions can include C atoms* **For other structures that might be creditworthy, contact TL**	**3**	**ALLOW** –3 for 3– **IGNORE** charges or dipoles on atoms within diagrams (even if wrong) Square brackets **NOT** required --- **3D** Must contain 2 'out wedges', 2 'in wedges' and 2 lines in plane of paper **OR** 4 lines, 1 'out wedge' and 1 'in wedge': For bond into paper, **ALLOW**:  **ALLOW** following geometry throughout:  **NOT ALLOW** structures showing a simplified loop for ethanedioate ligands e.g. 
	(b)	(i)	Colourless to yellow ✓	**1**	**IGNORE** clear for colourless

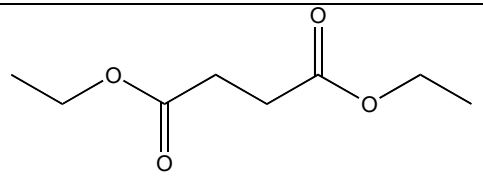
Question			Answer	Marks	Guidance
	(b)	(ii)	**Mean titre 1 mark** $= \frac{(23.15 + 23.25)}{2} = 23.2(0)\ (cm^3)$ ✓ **Analysis of results 5 marks** $n(Ce^{4+}) = 23.20 \times \frac{0.0500}{1000} = 1.16 \times 10^{-3}$ (mol) ✓ $n((COOH)_2)$ in 25.0 $cm^3 = \frac{1.16 \times 10^{-3}}{2} = 5.8(0) \times 10^{-4}$ (mol)✓ $n((COOH)_2)$ in 250 cm^3 $= 5.8(0) \times 10^{-4} \times 10 = 5.8(0) \times 10^{-3}$ (mol) ✓ Mass $(COOH)_2 = 5.8(0) \times 10^{-3} \times 90.0 = 0.522$ g ✓ % oxalic acid $= \frac{0.522 \times 100}{82.68} = 0.631\%$ ✓ Percentage **MUST** be expressed to **3 SF**	6	**Common error:** Incorrect mean from all 3 titres = 23.30 cm^3 **Use ECF throughout** Intermediate values for working to **at least 3 SF.** **TAKE CARE** as value written down may be truncated value stored in calculator. Depending on rounding, either can be credited. **----------** **COMMON ERRORS:** Mean of 23.30 (use of all 3 titres) → 0.634%: 5 marks **TAKE CARE** for final answer of 0.63 seen. • No final mark as only 2 SF • 0.63 may have been rounded from 0.631 (from correct mean) **OR** from 0.634 (using mean from all 3 titres) Check back to mean titre. No ÷2 to *obtain $n((COOH)_2)$* → 1.26%: 5 marks from 23.20 → 1.27% 4 marks from 23.30
			Total	**10**	

Question			Answer	Marks	Guidance
4	(a)	(i)	+2 **Sign required**	1	**ALLOW** 2+ **OR** +II **ALLOW** Pt^{2+}
		(ii)	 Curly arrow from lone pair on NH_3 to Pt ✓ $[PtCl_3(NH_3)]^-$ drawn with 1 Pt, 3 Cls and 1 NH_3 **AND** Curly arrow from **any** Pt–C*l* bond in the complex ✓ **ALLOW** S_N1 mechanism:  Mark curly arrows as above for S_N2 Requires + on platinum intermediate	2	For $[PtCl_3(NH_3)]^-$: • **IGNORE** dipoles • **IGNORE** absence of – charge • **IGNORE** – charge shown on atoms **ALLOW** any 4 coordinate shape for $[PtCl_3(NH_3)]^-$, e.g. tetrahedral; —Pt— **1st curly arrow** must • go to Pt **AND** start from, **OR** be traced back to **any point across width** of lone pair on N of NH_3  **DO NOT ALLOW** charge on NH_3 nucleophile, e.g. NH_3^- **2nd curly arrow** must start from, **OR** be traced back to, **any part of** Pt–Cl bond and go to one of the 3 Cl atoms 

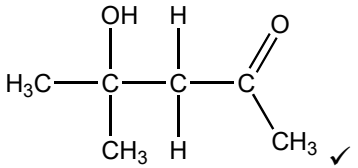
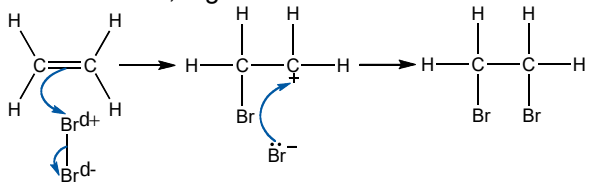
Question			Answer	Marks	Guidance
	(b)	(i)	Phenol ✓ Amide ✓ • **IGNORE** attempt to classify amide, e.g. secondary	2	**IF > 2** functional groups are shown, • Mark 2 groups **ONLY** • Mark incorrect groups **first** Treat carbonyl with aldehyde **OR** with ketone as one functional group, i.e. • carbonyl, aldehyde • carbonyl, ketone • carbonyl **IGNORE** aryl **OR** alkyl group e.g. benzene, phenyl, aryl, arene, methyl **IGNORE** hydroxyl/hydroxy
	(b)	(ii)*	*Refer to marking instructions on page 5 of mark scheme for guidance on marking this question.* **Level 3 (5-6 marks**) A correct calculation of the mass of 4-nitrophenol**.** **AND** Identifies the reagents **AND** intermediate. **AND** A **detailed** description of most purification steps. *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)** Calculates the mass of 4-nitrophenol with some errors **AND** suggests reagents and intermediate with some omissions. **OR** Calculates the mass of 4-nitrophenol with some errors **AND** describes some purification steps, with some detail. **OR**	6	**Indicative scientific points may include:** **<u>Calculation of mass of 4-nitrophenol</u>** **Using moles** • n(paracetamol) = $\frac{5.00}{151}$ = 0.0331 (mol) • n(4-nitrophenol) = 0.0331 × $\frac{100}{40}$ = 0.0828 (mol) • Mass of 4-nitrophenol = 139 × 0.0828 = 11.5 g **ALLOW** 11.4–11.6 for small slip/rounding **Using mass** • Theoretical mass paracetamol = 5.00 × $\frac{100}{40}$ = 12.5 g • Theoretical n(4-nitrophenol) = $\frac{12.5}{151}$ = 0.0828 (mol) • Mass of 4-nitrophenol = 139 × 0.0828 = **11.5** g **NOTE**: Incorrect inverse ratio of $\frac{100}{40}$ gives:

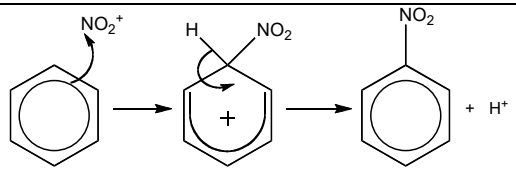
Question			Answer	Marks	Guidance
			Suggests reagents and intermediate with some omissions **AND** describes some purification steps, with some detail. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1-2 marks)** Attempts to calculate the mass of 4-nitrophenol **OR** Suggests reagents **OR** intermediate but may be incomplete **OR** Describes few purification steps. *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.		• $0.0331 \times \frac{40}{100} = 0.0132$ (mol) • Mass = $139 \times 0.0132 = 1.84$ g **Reagents and intermediate** • **Reagents:** Sn + (conc) HCl (then NaOH) • **Intermediate***:* 4-aminophenol or structure **Purification** • Dissolve impure solid in **minimum volume of** hot solvent • **Cool** solution and filter solid • **Scratch with glass rod** • **Wash** with cold solvent/solvent and **dry** **Examples** of detail in **bold** (**NOT INCLUSIVE**) **NOTE**: 'Recrystallisation' on its own is **NOT** a detailed description
			Total	**11**	

Question			Answer	Marks	Guidance
5	(a)		**TAKE CARE: Correct final answer of –52.3 OR –52.25 can be obtained from two cancelling errors:** • Use of 50 for energy released (no ×2 of 50 for two solutions mixed) • No ÷ 2 in final step **–52.3 OR –52.25 would then be awarded 2 marks out of 4** --- ***Correctly calculates n(succinic acid)*** $= 0.400 \times \frac{50.0}{1000} = 0.02(00)$ (mol) ✓ ***Energy released in J OR kJ*** $= 100.00 \times 4.18 \times 5.0 = 2090$ (J) **OR** 2.090 (kJ) ✓ **Energy released, in kJ or J, for formation of 2 mol H_2O** $\pm \frac{2090}{0.0200} = \pm 104500$ (J) **OR** $\pm \frac{2.090}{0.0200} = \pm 104.5$ **OR** ± 105 (kJ) ✓ **$\Delta_{neut}H$ to 3 or more SF AND correct – sign** $= -\frac{104.5}{2} = -52.3$ **OR** – 52.25 kJ mol^{-1} ✓	4	**ALLOW ECF throughout** **DO NOT ALLOW** less than 3 SF **IGNORE** units --- **ALTERNATIVE METHOD** ***n(succinic acid)*** = 0.02(00) (mol) ✓ ***Energy released*** = 2090 (J) **OR** 2.090 (kJ) ✓ **$n(H_2O)$ formed** = $2 \times 0.02(00) = 0.04(00)$ (mol) ✓ $\Delta_{neut}H = -\frac{2.090}{0.0400} = -52.3$ **OR** – 52.25 kJ mol^{-1} ✓
	(b)	(i)	Titration ✓	1	**IGNORE** type of titration
		(ii)	$(CH_2COOH)_2 + 2C_2H_5OH \rightleftharpoons (CH_2COOC_2H_5)_2 + 2H_2O$ ✓	1	**ALLOW** → instead of ⇌ sign **ALLOW** molecular formulae or hybrid formulae *Structures provided on QP* e.g. $C_4H_6O_4 + 2C_2H_6O \rightleftharpoons C_8H_{14}O_4 + 2H_2O$

Question			Answer	Marks	Guidance
		(iii)	 ✓	1	**IGNORE** displayed formulae
		(iv)	Volume cancels **OR** Same number of moles on each side of equation ✓	1	**ALLOW** units cancel **ALLOW** (sum of) balancing numbers/coefficients on each side of equation are the same **OR** same number of (moles of) reactants and products **IGNORE** volume is the same; K_c has no units
		(v)	**Moles of equilibrium products** ***1 mark*** $n((CH_2COOC_2H_5)_2)$ = 0.0300 (mol) **AND** $n(H_2O)$ = 0.0600 (mol) ✓ **Moles of C_2H_5OH** ***1 mark*** $n(\mathbf{C_2H_5OH})$ = 0.150 – 0.060 = 0.0900 (mol) ✓ **K_c calculated** ***1 mark*** $= \frac{0.03 \times 0.06^2}{0.02 \times 0.09^2}$ = 0.667 **OR** 0.67 ✓ **NOTE:** 0.02 must be used for *n*(succinic acid)	3	**ALLOW ECF** **ALLOW** 0.66, 0.666, etc. (**2 SF** and more) *Treated as meaning 0.6 recurring* **ALLOW** 2/3 **IGNORE** any units
			Total	11	

Question			Answer	Marks	Guidance
6	(a)	(i)	3-hydroxybutanal ✓	1	**ALLOW** 3-hydroxybutan-1-al **IGNORE** lack of hyphens or addition of commas **ALLOW** 4-oxobutan-2-ol **OR** 1-oxobutan-3-ol **DO NOT ALLOW** • 3-hydroxybutal • 3-hydroxylbutanal
		(ii)	Addition ✓	1	**IGNORE** nucleophilic **OR** electrophilic **OR** radical **DO NOT ALLOW** addition–elimination, condensation, polymerisation
		(iii)	**ALLOW** any formula provided that number and type of atoms and charge are correct, e.g. For CH_3CHO, **ALLOW** CH_3COH, C_2H_4O, etc. --- **Step 1**: • Correct equation ✓ • One correct acid–base pair ✓ i.e. A1 and B1 **OR** A2 and B2 $CH_3CHO + OH^- \rightleftharpoons {}^-CH_2CHO + H_2O$ **OR** $CH_3CHO + OH^- \rightleftharpoons CH_3CO^- + H_2O$ **A1 B2 B1 A2** **OR** **A2 B1 B2 A1** **Step 2**: $CH_3CHO + {}^-CH_2CHO + H_2O \rightarrow CH_3CHOHCH_2CHO + OH^-$ ✓	3	Throughout, **IGNORE** 'connectivity in any formula or structures shown. Examples in Answer column and in 6a(iv) guidance below --- **Step 1: ALLOW** H^+ transfer from OH^-, i.e. $CH_3CHO + OH^- \rightleftharpoons CH_3CH_2O^+ + O^{2-}$ ✓ **B2 A1 A2 B1** ✓ **OR** **B1 A2 A1 B2** **Step 2:** $CH_3CHO + CH_3CH_2O^+ + O^{2-} \rightarrow CH_3CHOHCH_2CHO + OH^-$ ✓

Question			Answer	Marks	Guidance
			For $^{-}CH_2CHO$: **ALLOW** CH_2CHO^{-}; CH_3CO^{-}; $C_2H_3O^{-}$ For $CH_3CHOHCH_2CHO$, **ALLOW** $C_4H_8O_2$		For $CH_3CH_2O^{+}$: **ALLOW** CH_3CHOH^{+}, $C_2H_5O^{+}$
		(iv)	 ✓	1	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous For connectivity, **ALLOW** OH| |CH_3– C_3H– OH— CH_3 *(Connectivity not being assessed)*
	(b)		*Refer to marking instructions on page 5 of mark scheme for guidance on marking this question*. **Level 3 (5–6 marks)** Describes, in detail, electrophilic reactions and mechanisms of one aliphatic **AND** one aromatic compound. *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)** Describes, in detail, an electrophilic reaction and mechanism of one aliphatic **OR** one aromatic compound. **OR** Describes electrophilic reactions and mechanisms of one aliphatic **AND** one aromatic compound, with few omissions/errors. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.*	6	**Indicative scientific points may include:** **Explanation of role of electrophiles in organic chemistry** **Reaction of aliphatic compound and mechanism** • Suitable reaction, e.g. ethene and Br_2 *May be shown within mechanism* • Mechanism, e.g.  **Reaction of aromatic compound and mechanism** • Suitable reaction, e.g. benzene + Cl_2 ; HNO_3 *May be shown within mechanism* • Mechanism, e.g.

Question			Answer	Marks	Guidance
			Level 1 (1–2 marks) Selects suitable reagents for electrophilic reactions of one aliphatic **AND** one aromatic compound. **OR** Attempts to describe an electrophilic reaction and mechanism of one aliphatic **OR** one aromatic compound, with omissions/errors. *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.*		 **Examples of a detailed description (NOT INCLUSIVE)** • Electrophile as electron pair acceptor • Types and names of mechanisms • Equations for generation of electrophile and regeneration of catalyst • Accurately positioned and directed curly arrows and charges/ dipoles included • Explanation of major and minor product from electrophilic addition
			Total	**12**	

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