Mark Scheme (Results)

Summer 2018

Pearson Edexcel GCE
In Chemistry (9CH0) Paper 03
General and Practical Principles in Chemistry

Edexcel and BTEC Qualifications

Summer 2018
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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Acceptable Answers	Additional Guidance	Mark
1(a)(i)	An answer that makes reference to the following points: **setting up of the dipole** • uneven distribution of **electrons** / (random) movement of **electrons /** (random) fluctuations of **electrons** **(1)** **type of dipole** • (results in an) instantaneous dipole / temporary dipole (in the first molecule) **(1)** **induction of a second dipole** • causes/induces a (second) dipole on another molecule **(1)**	M1 & M3 could be scored for an appropriate diagram Allow "Change in **electron** density" Allow "transient dipole" / "oscillating dipole" Do not award for "permanent dipole" Allow neighbouring molecule / adjacent molecule Do not award for "permanent dipole"	**(3)**

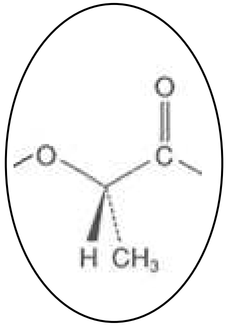
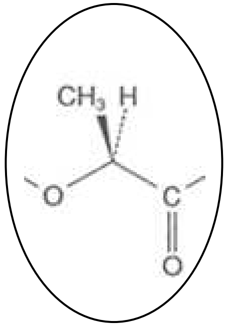
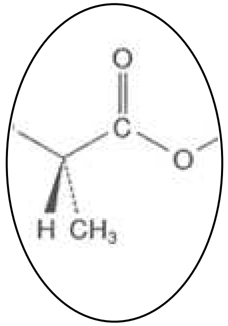
Question Number	Acceptable Answers	Additional Guidance	Mark
1(a)(ii)	An explanation that makes reference to the following points: **relative number of electrons** • bromine has more **electrons** (than chlorine) / bromine has one more shell of **electrons** (than chlorine) **(1)** **relative strength of intermolecular forces** • (so) bromine has stronger (London) forces (between molecules) / more (heat) energy is needed to overcome the London forces between bromine molecules / greater temporary dipole – induced dipole forces **(1)**	Allow reverse arguments Allow correct formulae Bromine has 35/70 electrons and chlorine has 17/34 electrons Ignore comments about protons, molecular mass etc Do not award "more outer shells" Ignore comments about 'points of contact' Allow more (London) forces Allow "bonds between molecules" Award **(0)** marks overall if any implication that **covalent** bonds are broken (on boiling)	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
1(b)	An answer that makes reference to the following points: **mixing of 1st pair of solutions** • mix Br_2 with KCl **(1)** **mixing of 2nd pair of solutions** • mix Br_2 with KI **or** mix I_2 with KBr **(1)** **colours of halogen (in cyclohexane)** • colour seen for experiment 1/ bromine is orange / yellow **and** colour seen for experiment 2/ iodine is purple / pink / violet / lilac **(1)** **correct ionic equation** • $Br_2 + 2I^- \rightarrow 2Br^- + I_2$ **(1)** • use of ONLY two correct experiments as above **(1)**	Ignore any reference to any additional reactions, e.g. with silver nitrate Award mark if correct ionic equation is given Ignore colours before the addition of cyclohexane Do not award brown Do not award red Allow multiples Ignore state symbols even if incorrect	**(5)**

(Total for Question 1 = 10 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
2(a)	An answer that makes reference to the following points: (1st Step) • HCN (and KCN) **(1)** • Nucleophilic addition **(1)** • $CH_3CHO + HCN \rightarrow CH_3CH(OH)CN$ **(1)** (2nd Step) • Any identified (dilute) strong acid / H^+ **(1)** • Heat (under reflux) / reflux **(1)** • Hydrolysis **(1)** • $CH_3CH(OH)CN + 2H_2O + H^+ \rightarrow CH_3CH(OH)COOH + NH_4^+$ **or** $CH_3CH(OH)CN + 2H_2O \rightarrow CH_3CH(OH)COOH + NH_3$ **(1)**	Ignore references to other conditions / solvent in step 1 Allow HCN and CN^- / H^+ and CN^- / H^+ and KCN **or** KCN and H_2SO_4 / KCN and HCl **or** HCN at pH 8 – 9 M1 can be scored for the appearance of HCN in M3 Do not award additional incorrect reaction types e.g. nitrification Allow skeletal formulae in equations M4, 5 & 6 dependent on the formation of any nitrile in step 1 Allow sodium hydroxide followed by acid Do not award conc. acid / just “acidify” / just “acid” Allow warm Do not award additional incorrect reaction types Allow two equations involving NaOH and H^+ Allow $CH_3CH(OH)CN + 2H_2O + HCl \rightarrow CH_3CH(OH)COOH + NH_4Cl$	**(7)**

Question Number	Acceptable Answers	Additional Guidance	Mark
2(b)(i)	• Condensation (polymerisation)	Ignore esterification or addition-elimination Do not award addition	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
2(b)(ii)	• Repeat unit circled on diagram as follows:  **or** 	Allow any repeat unit e.g  Do not award circle containing more than one repeat unit	**(1)**

(Total for Question 2 = 9 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
3(a)	0.816 / 8.16 x 10^{-1} (g)		**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
3(b)	• calculation of moles of CO_2	Example of calculation: (moles CO_2 = $\frac{225}{24000}$ =) 0.009375 Allow 9.375 x 10^{-3} / 9.38 x 10^{-3} / 9.4 x 10^{-3} Ignore SF except 1SF	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
3(c)	• moles of MCO_3 **(1)** • method for calculation of molar mass of MCO_3 **(1)** • molar mass final answer to 1, 2 or 3 SF **(1)** • consequential identification of Group 2 metal by name or formula **(1)** NOTE Alternative method can score 3 MAX Calculation of moles of CO_3^{2-} **(1)** (Calculation of mass of CO_3^{2-}) Deduction of mass of M by subtraction **(1)** Calculation of Ar of M to 1, 2 or 3 SF **AND** Identification of group 2 metal **(1)**	<u>Example of calculation</u>: Moles of MCO_3 = moles CO_2 = 0.009375 (mol) Molar mass of MCO_3 = $\frac{0.816}{0.009375}$ (= 87.04 (g mol^{-1})) M2 subsumes mark for M1 = 87.0 / 87 / 90 (g mol^{-1}) NOTE M3 mark subsumes mark for M2 and M1 (87.0 – 60) = 27 **AND** Mg / Magnesium / $MgCO_3$ Allow TE on answers to parts (a) and (b), with Metal consequential on calculated molar mass but M must be a Group 2 element Moles CO_3^{2-} = 0.009375 (Mass of CO_3^{2-} = 0.009375 x 60 = 0.5625 g) Mass of M = 0.2535 g Ar = 0.2535/0.009375 = 27.0 / 27 / 30 (g mol^{-1}) **AND** Mg / Magnesium / $MgCO_3$	(4)

Question Number	Acceptable Answers	Additional Guidance	Mark
3(d)(i)	An explanation that makes reference to the following points: • the bung was not replaced quickly enough **(1)** • (So) CO_2 / gas lost (to the surroundings) **(1)**	Allow bung not fitting tightly resulting in leaks Ignore references to CO_2 dissolving Ignore references to other types of gas leak Allow 'smaller volume of gas collected' / lower reading of gas volume Mark points M1 and M2 independently	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
3(d)(ii)	An answer that makes reference to the following point: The acid was (already) in excess (and more acid won't affect this)	Allow The carbonate is the limiting reactant / the acid is not the limiting reactant	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
3(d)(iii)	An explanation that makes reference to the following points: • rate of reaction is faster **and** powder has greater surface area **(1)** • no effect on (final) volume of gas **and** moles of (metal) carbonate are unchanged **or** because the rate is faster more gas will be lost before the bung is replaced so the (final) volume will be less **(1)**	Mark points M1 and M2 independently Both parts of statement needed Both parts of statement needed Allow mass / amount for moles Allow reactant for metal carbonate	**(2)**

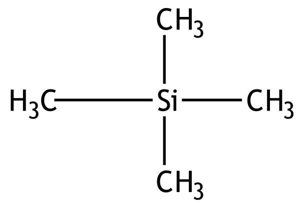
Question Number	Acceptable Answers	Additional Guidance	Mark
3(e)(i)	• balanced equation with state symbols	Example of equation: $MCO_3(s) \rightarrow MO(s) + CO_2(g)$ Allow a correct equation for the decomposition of any Group 2 carbonate	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
3(e)(ii)	• subtractions to obtain masses **(1)** • calculation of moles of CO_2 **(1)** • calculation of molar mass of MCO_3 **(1)**	Example of calculation: (mass of CO_2 = 20.447 – 20.205) = 0.242 **AND** (mass of MCO_3 = 20.447 – 19.996) = 0.451 moles of $CO_2 = \frac{0.242}{44}$ = 0.0055(0) (mol) / 5.5(0) x 10^{-3} (mol) ALLOW TE from M2 to M3 Mr of $MCO_3 = \frac{0.451}{0.0055(0)}$ = 82 (g mol^{-1}) Correct answer with or without working scores 3 Ignore SF except 1 Ignore attempts to identify the metal	**(3)**

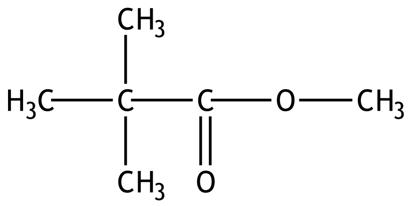
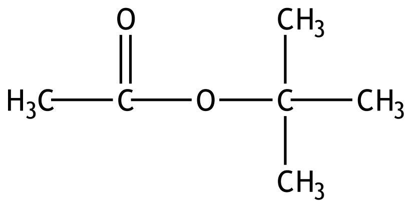
Question Number	Acceptable Answers	Additional Guidance	Mark
3(f)	An answer that makes reference to the following point: Student 3 used a smaller mass / less (and the uncertainty of the balance was the same) **or** Student 1 used a larger mass / more (and the uncertainty of the balance was the same)	Allow calculations comparing the two percentage errors: e.g. Student 1:- (0.001/0.816) x 100% = 0.12% **and** Student 3:- 0.001/0.451 x 100% = 0.22%	**(1)**

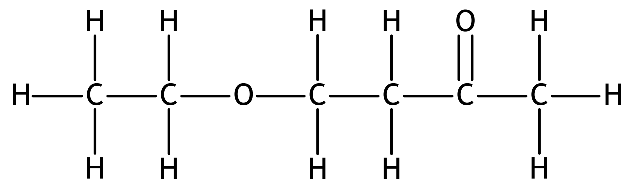
Question Number	Acceptable Answers	Additional Guidance	Mark
3(g)	An explanation that makes reference to the following points: • more CO_2 (would appear to be) given off **(1)** • (So) calculated molar mass is smaller **(1)** **OR** • Less MO would appear to have been formed **(1)** • Calculated molar mass would be greater **(1)**	 M2 dependent on M1 M2 dependent on M1	**(2)**

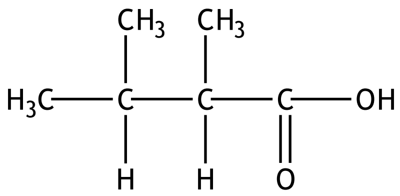
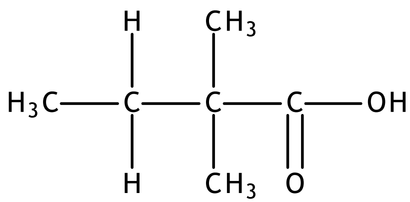
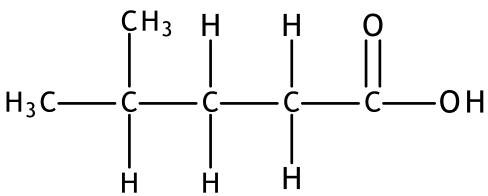
(Total for Question 3 = 18 marks)

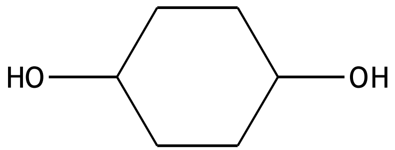
Question Number	Acceptable Answers	Additional Guidance	Mark
4(a)(i)	$(CH_3)_4Si$	Allow partially or fully displayed formula Ignore connectivity 	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
4(a)(ii)	An answer that makes reference to any **two** of the following: • single peak / all H or all C in same environment / no splitting pattern **(1)** • (TMS) peak to the right / upfield / out of the way of other peaks / peak doesn't overlap with other peaks **(1)** • (TMS) low boiling temperature / volatile / can be easily removed **(1)** • gives a strong signal so only a small amount needed **(1)**	Allow 12 H or 4 C in the same environment Ignore references to inertness / non-toxicity / cost / non-polar(ity) Ignore chemical shift = 0 12 H / 4 C are equivalent so gives a strong signal scores 2 marks	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
4(b)(i)	$C(CH_3)_3COOCH_3$ **or**  **(1)** $CH_3COOC(CH_3)_3$ **or**  **(1)**	Allow displayed or skeletal formulae	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
4(b)(ii)	An answer that makes reference to the following points:		**(5)**
	• the chemical shift δ 2.2 identified **(1)**	$CH_3C{=}O$ / methyl attached to C=O	
	• four remaining chemical shifts identified **(2)**	Identifies 2 or 3 chemical shifts correctly scores 1 δ 1.2 3.5 3.8 2.6 (2.2) 	
	• two splitting patterns given **and** explained **(2)**	1 specific splitting patterns explained scores 1	

Question Number	Acceptable Answers	Additional Guidance	Mark
4(c)(i)	Any two of the following $(CH_3)_2CHCH(CH_3)COOH$ /  **(1)** $CH_3CH_2C(CH_3)_2COOH$ /  **(1)** $(CH_3)_2CHCH_2CH_2COOH$ /  **(1)**	Allow displayed or skeletal formulae	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
4(c)(ii)		Do not award other types of structure	**(1)**

(Total for Question 4 = 13 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
5(a)	+5	Allow 5+ / +V / V+ / (V) / 5 Do not award V^+	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
5(b)	A description that makes reference to the following points: **M1 and M2 –colours** Yellow → blue → green → violet / lavender / purple / mauve 2 or 3 colours linked to correct species / oxidation states / reactions **(1)** 4 colours linked to correct species / oxidation states / reactions **(1)** **M3 - statement** Statement that sequence is from +5 to +4 to +3 to +2 **or** (step-wise) reduction / zinc is a reducing agent **(1)** **M4, M5 and M6 - equations** These three equations, **with** appropriate $E^\ominus$ values $Zn + 2VO_3^- + 8H^+ \rightarrow Zn^{2+} + 2VO^{2+} + 4H_2O$ **and** $E^\ominus$ = (+)1.76 (V) **(1)** $Zn + 2VO^{2+} + 4H^+ \rightarrow Zn^{2+} + 2V^{3+} + 2H_2O$ **and** $E^\ominus$ = (+)1.1(0) (V) **(1)** $Zn + 2V^{3+} \rightarrow Zn^{2+} + 2V^{2+}$ **and** $E^\ominus$ = (+)0.5(0) (V) **(1)** **M7 – stops at V^{2+}** No (further) reduction (feasible) to V metal / V(0) **or** $Zn + V^{2+} \rightarrow Zn^{2+} + V$ not feasible **or** $E^\ominus$ = **−**0.42 (V) **(1)**	M3 can be implied from species in explanation or equations Allow multiples Ignore state symbols even if incorrect 3 correct equations with incorrect $E^\ominus$ scores 2 2 correct equations with incorrect $E^\ominus$ scores 1 3 correct $E^\ominus$ with incorrect equations scores 1	**(7)**

Question Number	Acceptable Answers	Additional Guidance	Mark
5(c)	A explanation that makes reference to the following points: M1 V changes (its oxidation state / oxidation number) from +5 to +4 (as it oxidises the sulfur dioxide) OR The oxidation number of V decreases in the reaction OR Vanadium is reduced in the reaction with SO_2 OR V_2O_5 oxidises the SO_2 / S OR $V_2O_5 + SO_2 \rightarrow V_2O_4 + SO_3$ **(1)** M2 (Then) returns to +5 (oxidation state / oxidation number) by reacting with oxygen OR $2\ V_2O_4 + O_2 \rightarrow 2\ V_2O_5$ **(1)**	Ignore any references to heterogeneous catalysis Allow Forms V_2O_4 / VO_2 (as an intermediate) Do not award VO^{2+} or VO_3^- or VO_2^+ Allow (re-) forms V_2O_5	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
***5(d)**	This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content. <table><tr><td>Number of indicative marking points seen in answer</td><td>Number of marks awarded for indicative marking points</td></tr><tr><td>6</td><td>4</td></tr><tr><td>5–4</td><td>3</td></tr><tr><td>3–2</td><td>2</td></tr><tr><td>1</td><td>1</td></tr><tr><td>0</td><td>0</td></tr></table> The following table shows how the marks should be awarded for structure and lines of reasoning.	Guidance on how the mark scheme should be applied: The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning). If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages). In general it would be expected that 5 or 6 indicative points would score 2 reasoning marks, and 3 or 4 indicative points would score 1 reasoning mark. A total of 2, 1 or 0 indicative points would score 0 marks for reasoning. If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s).	**(6)**

Indicative content (IPs)	
IP1: • $[Cu(H_2O)_6]^{2+}(aq) + 2OH^-(aq) \rightarrow [Cu(OH)_2(H_2O)_4](s) + 2H_2O(l)$	Allow omission of square brackets throughout Allow for IP1 $Cu^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s)$ Only penalise incorrect or missing state symbols in this equation (IP1)
IP2: • blue ppt / blue solid (when $[Cu(OH)_2(H_2O)_4](s)$ is formed)	
IP3: • $[Cu(H_2O)_6]^{2+}(aq) + 4NH_3(aq) \rightarrow [Cu(NH_3)_4(H_2O)_2]^{2+}(aq) + 4H_2O(l)$	Allow for IP3 $Cu^{2+}(aq) + 4NH_3\ (aq) \rightarrow [Cu(NH_3)_4]^{2+}(aq)$ $[Cu(OH)_2(H_2O)_4](s) + 4NH_3\ (aq) \rightarrow [Cu(NH_3)_4(H_2O)_2]^{2+}(aq) + 2H_2O(l) + 2OH^-(aq)$ $[Cu(OH)_2(H_2O)_4](s) + 6NH_3\ (aq) \rightarrow [Cu(NH_3)_4(H_2O)_2]^{2+}(aq) + 2NH_4^+\ (aq)\ 2H_2O(l) + 2OH^-(aq)$ Ignore formation of initial precipitate $Cu(OH)_2(s)$ Do not award $[Cu(NH_3)_6]^{2+}(aq)$
IP4: • Deep blue solution / dark blue solution (when $[Cu(NH_3)_4(H_2O)_2]^{2+}(aq)$ is formed)	
IP5: • $[Cu(H_2O)_6]^{2+}(aq) + 4Cl^-(aq) \rightarrow [CuCl_4]^{2-}(aq) + 6H_2O(l)$	
IP6: • Yellow / green (solution when $[CuCl_4]^{2-}(aq)$ is formed)	Do not award 'yellow precipitate' Allow equilibrium sign ⇌ in any reaction Ignore any initial colours, even if incorrect

(Total for Question 5 = 16 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
6(a)(i)	An answer that makes reference to the following points: • 3300 — 2500 (cm^{-1}) **and** O-H (bond) **(1)** • 1725 — 1700 (cm^{-1}) **and** C=O (bond) **(1)**	Allow any value(s) within the range 3300 — 2500 (cm^{-1}) Allow -OH Allow any value(s) within the range 1725 — 1700 (cm^{-1}) Allow 1320 – 1210 (cm^{-1}) **and** C-O	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
6(a)(ii)	An answer that makes reference to the following points: • structures 1 and 2 will have an absorption at Either C=C at 1669 — 1645 (cm^{-1}) **or** C—H in an alkene at 3095 — 3010 (cm^{-1}) **(1)** • only structure 2 will have an absorption due to the presence of an alcohol / O—H at 3750 —3200 (cm^{-1}) **(1)** • structure 3 will have none of these absorptions / will not show C=C absorption / C-H absorption for an alkene **(1)**	Reject C=C at 3010 (cm^{-1})	**(3)**

Question Number	Acceptable Answers	Additional Guidance	Mark
6(b)	• calculation of moles of NaOH **(1)** • calculation of mass of NaOH **(1)**	Example of calculation: (moles NaOH = $0.140 \times \frac{250}{1000}$) = 0.035(0) (mol) = 40(.0) x 0.035(0) = 1.4(0) (g) Correct answer with or without working scores 2 marks Allow TE for M2 on moles of NaOH Alternative route, allow M1 for conversion of concentration to 5.6 g dm^{-3} Ignore SF	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
6(c)(i)	An explanation that makes reference to the following points: • (because the) sodium hydroxide has been diluted **(1)** • (the titre will be) smaller **(1)**	Allow Fewer moles of sodium hydroxide present / some sodium hydroxide will have been removed M2 dependent on M1	**(2)**

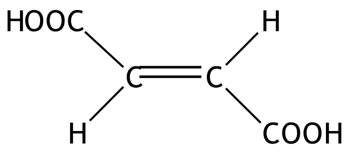
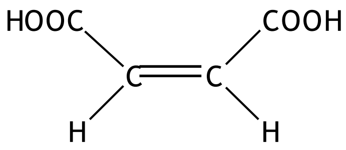
Question Number	Acceptable Answers	Additional Guidance	Mark
6(c)(ii)	An explanation that makes reference to the following points: M1 no effect (on the titre) **(1)** M2 because the (number of) moles of sodium hydroxide is unaffected **(1)**	 M2 depends on M1 Allow base / alkali / hydroxide (ions) Allow amount / mass of sodium hydroxide is unaffected	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
6(c)(iii)	• calculation of percentage uncertainty in burette volume **(1)** • calculation of percentage uncertainty in volumetric flask volume **and** in pipette volume **(1)** • identification of volume with the lowest percentage uncertainty **(1)**	Example of calculation: $\frac{2 \times (\pm)0.05}{10.20} \times 100\% = (\pm)0.980392156\%$ $\frac{(\pm)0.30}{250.0} \times 100\% = (\pm)0.12\%$ **and** $\frac{(\pm)0.040}{10.0} \times 100\% = (\pm)0.4\%$ Volumetric flask has the lowest uncertainty Allow TE for identification in M3 Allow ANY number of SF in answer, from 1 SF up to calculator value	**(3)**

Question Number	Acceptable Answers	Additional Guidance	Mark
6(d)(i)	• left-hand side of equation correct **(1)** • right-hand side of equation correct **(1)**	<u>Example of equation</u> HOOCCH=CHCOOH + 2NaOH → NaOOCCH=CHCOONa + $2H_2O$ ALLOW use of molecular formulae or ionic equation: $C_4H_4O_4$ + 2NaOH → $Na_2C_4H_2O_4$ + $2H_2O$ HOOCCH=CHCOOH + $2OH^-$ (+ $2Na^+$) → $^-$OOCCH=CHCOO$^-$ + $2H_2O$ (+ $2Na^+$) ALLOW Multiples Correct charges Do not award if O−Na covalent bond drawn IGNORE State symbols, even if incorrect	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
6(d)(ii)	An answer that makes reference to the following points: • (New mean titre) = 20.4(0) (cm^3) / double (the original value) **(1)** • For structure 2, mole ratio / reacting ratio is 1:1 (with NaOH) **(1)**	Mark M1 and M2 independently Allow structure 2 has 1 COOH / 1 acid group	**(2)**

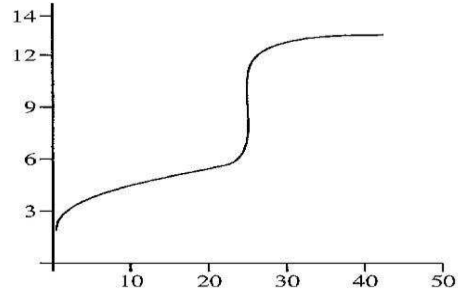
Question Number	Acceptable Answers	Additional Guidance	Mark
6(e)	<table><tr><th>Structure</th><th>Test with Br_2 water</th><th>Test with acidified $K_2Cr_2O_7$</th></tr><tr><td>HOOCCH=CHCOOH</td><td>✓</td><td>**x**</td></tr><tr><td>$HOCH_2CH=CHCH_2COOH$</td><td>✓</td><td>✓</td></tr><tr><td>$CH_3CH_2CH_2CH_2CH_2COOH$</td><td>**x**</td><td>**x**</td></tr></table> Left hand column correct **(1)** Right hand column correct **(1)**	3 correct ticks with no crosses scores 1 Ignore descriptions of result in terms of colour (changes) / reactions occurring	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
6(f)(i)	• *E*-isomer:  **(1)** • *Z*-isomer:  **(1)**	ALLOW skeletal or displayed structures ALLOW $-CO_2H$ IGNORE Connectivity to the −COOH group IGNORE bond angles Award one mark if correct structures are drawn, but *E*- and *Z*-isomers labelled the wrong way round Award 1 mark if incorrect molecule used but *E* - and *Z*- isomers are correct	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
6(f)(ii)	An answer that makes reference to the following points: • restricted / limited rotation (about the C=C double bond) **(1)** • each carbon atom in the double bond is attached to (two) different atoms / different groups (of atoms) / to a H (atom) and a COOH group **(1)**	Allow "no rotation" Do not award the carbons are attached to 2 "different molecules" Mark points M1 and M2 independently	**(2)**

(Total for Question 6 = 24 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
7(a)	• calculates moles of X^- / NaOH present in the mixture **(1)** • calculates moles of HX which remain unreacted **(1)** • calculates / shows ratio of [HX] to [X^-] OR ratio of moles of HX : X^- (as total V cancels) **(1)** • re-arranges K_a or pK_a expression correctly and substitutes appropriate values **(1)** • final pH to 2 or 3SF **(1)**	Example of calculation: (moles of X^- = mol NaOH = $\frac{0.8(00) \times 10.5}{1000}$) = 0.0084(0) / 8.4(0) x 10^{-3} (mol) (moles of HX – mol NaOH = $\frac{0.92(0) \times 25.0}{1000}$ **–** 0.0084(0) = 0.023(0) – 0.0084(0)) = 0.0146 / 1.46 x 10^{-2} (mol) [HX] = $\frac{0.0146}{0.0355}$ **and** [X^-] = $\frac{0.0084(0)}{0.0355}$ = 0.411 **and** 0.237 (mol dm^{-3}) Allow use of the ratio of the moles as above (as total V cancels) $[H^+] = K_a \times \frac{[HX]}{[X^-]} = 5.25 \times 10^{-5} \times \frac{0.411}{0.237}$ $[H^+]$ = 9.10443038 × 10^{-5} (mol dm^{-3}) pH = 4.04 Allow use of pH expression to get answer: pH = pK_a – log $\frac{[HX]}{[X^-]}$ or pK_a + log $\frac{[X^-]}{[HX]}$ ALLOW TE M5 for calculation of pH from any $[H^+]$ Correct answer with no working scores (5)	**(5)**

Question Number	Acceptable Answers	Additional Guidance	Mark
7(b)(i)	A sketch graph which shows the following: • a starting pH between 2 and 4 (inclusive) **(1)** • correct general shape and ends at pH = 12-13 **(1)** • (any) vertical at 25 cm^3 **(1)** • vertical between pH = 6 - 7 and pH = 10 – 12 **(1)**	 Vertical must be no more than 5 pH units within these ranges	**(4)**

Question Number	Acceptable Answers	Additional Guidance	Mark
7(b)(ii)	An explanation that makes reference to the following points: • (Read off) **pH** at half-neutralisation (point) / pH at 12.5 (cm^3) OR **pH** at half-equivalence (point) **(1)** • As pH = pK_a / [H^+] = K_a / K_a = 10^{-pH} **(1)**	May be shown on the sketch graph ALLOW read equivalence vol, add same volume of (propanoic) acid and measure pH M2 dependent on mentioning half equivalent / 12.5 cm^3	**(2)**

(Total for Question 7 = 11 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
8(a)	Any one from: Catalyst / speeds up reaction / increases rate / increases rate of attainment of equilibrium / lowers activation energy	Ignore any mention of protonation or mechanism for catalysis Do not award additional incorrect types of reaction	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
8(b)(i)	• calculation of moles of H^+ in 25.0 cm^3 **(1)** • calculation of moles of H^+ in 250 cm^3 flask **(1)**	Ignore SF throughout 8(b)(i) to 8(c)(ii) except 1 SF, which should be penalised once only <u>Example of calculation</u>: (moles NaOH = $0.200 \times \frac{23.60}{1000}$) = 0.00472 (mol) (= mol H^+ in 25.0 cm^3) (= 10 x 0.00472) = 0.0472 (mol) (in 250 cm^3) Allow TE for M2 on moles of NaOH Correct answer with or without working scores 2 marks	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
8(b)(ii)	• subtracts moles of H^+ in HCl from answer to (b)(i)	<u>Example of calculation</u>: 0.0472 – 0.00400 = 0.0432 (mol) Allow TE on answer to part (b)(i)	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
8(c)(i)	• calculation of moles of CH_3COOH that have reacted	Example of calculation: (0.105 — 0.0432) = 0.0618 Allow TE on part (b)(ii) unless negative value	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
8(c)(ii)	• calculation of equilibrium moles of $CH_3CH_2CH_2OH$ **(1)** • calculation of equilibrium moles of $CH_3COOCH_2CH_2CH_3$ **(1)** • calculation of equilibrium moles of H_2O **(1)**	Example of calculation: 0.0800 — 0.0618 = 0.0182 0.0618 0.111 + 0.0618 = 0.1728 Allow TE on answer to part (c)(i) unless negative value	**(3)**

Question Number	Acceptable Answers	Additional Guidance	Mark
8(d)(i)	(K_c =) $\frac{[CH_3COOCH_2CH_2CH_3][H_2O]}{[CH_3COOH][CH_3CH_2CH_2OH]}$	IGNORE state symbols even if incorrect Do not award round brackets	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
8(d)(ii)	An explanation that makes reference to the following points: • Same number of moles/molecules on both sides of the equation **(1)** • (so) volume / V cancels in K_c expression **(1)**	2 marks could be scored by a correct mathematical expression showing V or dm^3 cancel Allow same number of terms on top and bottom of K_c expression Allow units cancel out Allow "**all** divided by the same volume"	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
8(d)(iii)	• calculates value of K_c **(1)** • final value of K_c quoted to 2 or 3 SF **(1)**	<u>Example of calculation</u> $K_c = \frac{(0.0618) \times (0.1728)}{(0.0432) \times (0.0182)} = 13.58241758$ = 14 / 13.6 (no units) Correct answer with no working gains full marks Ignore units No TE on wrong K_c expression	**2**

Question Number	Acceptable Answers	Additional Guidance	Mark
8(e)	An explanation that makes reference to the following points: • the equilibrium shifts to the left **or** the mixture absorbs carbon dioxide from the atmosphere **(1)** • so the mixture is (becoming more) acidic / the acid reforms **(1)**	Mark independently Allow no longer alkaline Do not award just "pH decreases"	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
8(f)	An explanation that makes reference to the following points: • carry out / repeat experiment **and** leave for longer than a week **(1)** • the titre value / K_c value will remain unchanged (if equilibrium has been established) **(1)**	Ignore pH probes / checking pH Allow repeat experiment **and** check titres within first week Allow moles / concentration are unchanged Ignore just "results unchanged"	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
8(g)	An answer that makes reference to the following points: • K_c value will be greater than that calculated in (d)(iii) **(1)** • because the (forward) reaction is endothermic **or** backward / reverse reaction is exothermic **(1)**	M2 depends on M1 Ignore References to the equilibrium position shifting to the right (with increasing temperature)	**(2)**

(Total for Question 8 = 19 marks)

TOTAL FOR PAPER = 120 MARKS

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