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Mark Scheme (Results)

January 2014

IAL Chemistry (WCH05/01)

Unit 5: General Principles of Chemistry II

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January 2014
Publications Code IA037636

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.

Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
iii) organise information clearly and coherently, using specialist vocabulary when appropriate

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.

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	B		1

Question Number	Correct Answer	Reject	Mark
2	D		1

Question Number	Correct Answer	Reject	Mark
3	C		1

Question Number	Correct Answer	Reject	Mark
4	D		1

Question Number	Correct Answer	Reject	Mark
5	A		1

Question Number	Correct Answer	Reject	Mark
6	C		1

Question Number	Correct Answer	Reject	Mark
7	D		1

Question Number	Correct Answer	Reject	Mark
8	A		1

Question Number	Correct Answer	Reject	Mark
9	D		1

Question Number	Correct Answer	Reject	Mark
10	B		1

Question Number	Correct Answer	Reject	Mark
11	C		1

Question Number	Correct Answer	Reject	Mark
12	A		1

Question Number	Correct Answer	Reject	Mark
13	B		1

Question Number	Correct Answer	Reject	Mark
14	B		1

Question Number	Correct Answer	Reject	Mark
15	C		1

Question Number	Correct Answer	Reject	Mark
16	D		1

Question Number	Correct Answer	Reject	Mark
17	D		1

Question Number	Correct Answer	Reject	Mark
18	A		1

Question Number	Correct Answer	Reject	Mark
19	A		1

Question Number	Correct Answer	Reject	Mark
20	B		1

Total for Section A = 20 marks

Section B

Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	In 21(a) IGNORE State symbols even if incorrect Working in half equations (e.g. multipliers & cancelled $e^{(-)}$) $MnO_4^- + 8H^+ + 5e^{(-)} \rightarrow Mn^{2+} + 4H_2O$ ($E^\ominus$=1.51V) OR Multiples ALLOW reversible and double headed arrows	Electrons omitted	1

Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	$H_2O \rightarrow ½O_2 + 2H^+ + 2e^{(-)}$ ($E^\ominus$=1.23V) OR Multiples ALLOW reversible and double headed arrows Equation reversed $H_2O - 2e^{(-)} \rightarrow ½O_2 + 2H^+$	Electrons omitted	1

Question Number	Acceptable Answers	Reject	Mark
21(a)(iii)	$4MnO_4^- + 12H^+ \rightarrow 4Mn^{2+} + 5O_2 + 6H_2O$ OR $2MnO_4^- + 6H^+ \rightarrow 2Mn^{2+} + 5/2O_2 + 3H_2O$ ALLOW reversible and double headed arrows other multiples uncancelled H^+ and H_2O TE only on MnO_4^-|MnO_4^{2-} in (a)(i): $2MnO_4^- + H_2O \rightarrow 2MnO_4^{2-} + ½O_2 + 2H^+$	Uncancelled $e^{(-)}$	1

Question Number	Acceptable Answers	Reject	Mark
21(a)(iv)	$E^{\ominus}_{cell}$ = 1.51 – 1.23 = (+)0.28 (V) ALLOW TE on $E^{\ominus}_{cell}$ = −0.67 (V) derived from using MnO_4^-|MnO_4^{2-} if correct equation in (a)(iii) is reversed (1) $E^{\ominus}_{cell}$ is positive so reaction is (thermodynamically) feasible / manganate(VII) oxidizes the water / water reduces manganate(VII) ALLOW so thermodynamically spontaneous so reaction goes / possible so MnO_4^- unstable (1) No TE on negative $E^{\ominus}_{cell}$ unless correct equation in (a)(iii) is reversed.	Just 'reaction goes'	2

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	Distilled / deionised water need only be mentioned once. Dissolve solid in (a suitable volume (< 150 cm^3) of) distilled / deionised water / dilute sulfuric acid in a beaker (1) Transfer solution to a volumetric / graduated flask (1) add washings (1) Make up to mark / 250 cm^3 and mix (1) Preparing the solution in the volumetric flask max 2 (MP2 and MP4) ALLOW Any indication of mixing (e.g. swirl / invert)	Just 'water' conc H_2SO_4 conical flask Just 'flask'	4

Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	colourless /pale yellow to (first permanent pale) pink	purple to pink Purple / mauve	1

Question Number	Acceptable Answers	Reject	Mark
21(b)(iii)	$MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$ ALLOW multiples reversible and double headed arrows IGNORE state symbols even if incorrect	Uncancelled $e^{(-)}$	1

Question Number	Acceptable Answers	Reject	Mark
21(b)(iv)	Check the method: If the method is based on [MnO_4^-] being less than 0.02 mol dm^{-3} then correct answer with some working scores full marks. % MnO_4^- remaining = 98.6855 (%) with some correct working scores 3 Correct answer (1.31449 (%)) with no working scores 3 Calculation of the % of the Mohr's salt that has reacted before the titration (assumes [MnO_4^-] = 0.02 mol dm^{-3}) gives (about) the same value and scores max 3 Example of fully correct method Mol Fe^{2+} in 25 cm^3 = (10/392)x(25/250) (1) = 2.55102 x 10^{-3} (*) Mol MnO_4^- in 25.85 cm^3 = Answer */5 (1) = 2.55102 x 10^{-3} / 5 = 5.10204 x 10^{-4} (**) Conc^n of MnO_4^- = 1000 x Answer **/25.85 = 0.019737 mol dm^{-3} (***) (1) % reacted prior to the titration = 100 x (0.02 – Answer ***)/0.02 = 100 x (0.02 – 0.019737) / 0.02 = 1.31449 (%) (1) TE at each stage in the calculation unless conc^n MnO_4^- remaining greater than 0.02 (so % reacted negative) when max 2		
	Continued on next page		4

Question Number	Acceptable Answers	Reject	Mark
21(b)(iv) continued	A common incorrect calculation is Mol MnO_4^- in 25.85 cm^3 = 25.85 x 0.02/1000 = 5.17 $x10^{-4}$ (0) Mol Fe^{2+} in 25 cm^3 = 5 x 5.17 $x10^{-4}$ = 2.585 x 10^{-3} (1) Mol Fe^{2+} in 250 cm^3 = 10 x 5 x 5.17 $x10^{-4}$ = 2.585 x 10^{-2} Then Actual mol Fe^{2+} in 250 cm^3 = 10/392 = 2.551 $x10^{-2}$ Difference = 2.585$x10^{-2}$ - 2.551 $x10^{-2}$ =0.034 $x10^{-2}$ OR Mass of Mohr's salt = 392 x 2.585 x 10^{-2} = 10.1332 g so difference = 10.1332 – 10 = 0.1332 g (1) Percentage =100 x 0.034 $x10^{-2}$ / 2.585$x10^{-2}$ = 1.3153 (1) Where the calculation breaks down, marks may often be possible for MP1 (mol Fe^{2+} in 25 cm^3) MP2 (using 5:1 reacting ratio for Fe^{2+}: MnO_4^-) Ignore SF except 1 SF	1.3333	

Total for Question 21 = 15 marks

Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	If name and formula are given, both must be correct A = copper(II) chloride / $CuCl_2$ (1) B = tetrachlorocuprate(II) (ion) / $CuCl_4^{2-}$ ALLOW B = trichlorocuprate(II) / $CuCl_3^-$ (1) C = copper(II) hydroxide / $Cu(OH)_2$ / $Cu(OH)_2(H_2O)_4$ (1) D = tetraamminecopper(II) (ion) / $Cu(NH_3)_4^{2+}$ / $Cu(H_2O)_2(NH_3)_4^{2+}$ (1) E = copper(I) oxide / Cu_2O (1) F = iodine / I_2 / triiodide (ion) / I_3^- / KI_3 (1) IGNORE state symbols even if incorrect. correct oxidation numbers with formula. order of the ligands.	B = $CuCl_2$	6

Question Number	Acceptable Answers	Reject	Mark
22(a)(ii)	If name and formula are given, both must be correct X = (aqueous) ammonia / $NH_3(aq)$ ALLOW NH_3 / ammonium hydroxide (1) Y = potassium iodide / KI ALLOW other soluble iodides (1) IGNORE references to concentration	X = NaOH iodide / I^- KI and acid HI	2

Question Number	Acceptable Answers	Reject	Mark
22(a)(iii)	(Product is) ethanoic acid / CH_3COOH / ethanoate(ions) / CH_3COO^- (1) IGNORE carboxylic Ethanal is a reducing agent / reduces Cu^{2+} (1) Stand alone marks IGNORE references to oxidation of ethanol products of reduction (e.g. Cu)		2

Question Number	Acceptable Answers	Reject	Mark
22(a)(iv)	(Iodine is formed quantitatively and is determined by) titration against sodium thiosulfate solution (of known concentration)	Colorimetry	1

Question Number	Acceptable Answers	Reject	Mark
22(b)(i)	(3)d orbitals / (3)d subshell split (by the attached ligands) (1) Electrons are promoted (from lower to higher energy d orbital(s) / levels) OR Electrons move from lower to higher energy d orbital(s) / levels) ALLOW d—d transitions occur (1) Absorbing energy /photons of a certain frequency (in the visible region) ALLOW Absorbing light (1) Reflected / transmitted / remaining light is coloured / yellow / in the visible region ALLOW Complementary colour seen Reflected / transmitted / remaining light / frequency is seen (1) Penalise omission of (3)d once only. Ignore reference to electrons relaxing / dropping to the ground state	Orbital / shell is split	4

Question Number	Acceptable Answers	Reject	Mark
22(b)(ii)	Colour depends on the frequency /wavelength /energy of the absorbed light (1) Different ligands split the d orbitals to a different extent (1)		2

Question Number	Acceptable Answers	Reject	Mark
22(c)(i)	$2Cu^{+}(aq) \rightarrow Cu(s) + Cu^{2+}(aq)$ ALLOW reversible arrows	Electrons	1

Question Number	Acceptable Answers	Reject	Mark
22(c)(ii)	The copper(I) is oxidized to copper(II) and (in the same reaction) reduced to copper((0)) OR Copper changes from +1 to 0 and +2 IGNORE Reference to a Cu atom		1

Question Number	Acceptable Answers	Reject	Mark
22(c)(iii)	Relevant reduction potentials are $Cu^{2+} + e^{-} \rightleftharpoons Cu^{+}$ $E^{\ominus} = +0.15$ (V) $Cu^{+} + e^{-} \rightleftharpoons Cu$ $E^{\ominus} = +0.52$ (V) ALLOW single arrows (1) $E^{\ominus}_{cell} = 0.52 - 0.15 = (+)0.37$ (V) (1) TE on incorrect $E^{\ominus}$ values providing $E^{\ominus}_{cell}$ is positive ($E^{\ominus}_{cell}$ positive so reaction thermodynamically favourable)		2

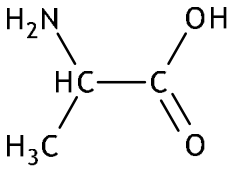
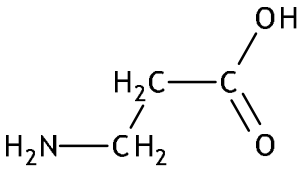
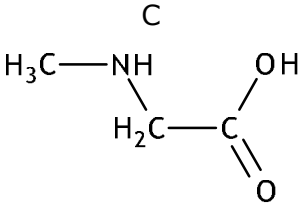
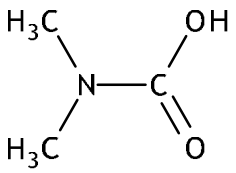
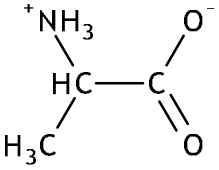
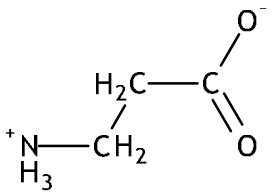
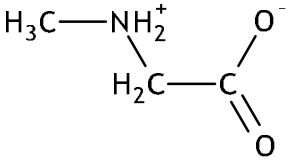
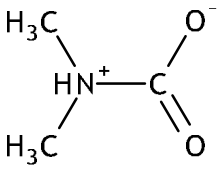
Total for Question 22 = 21 marks

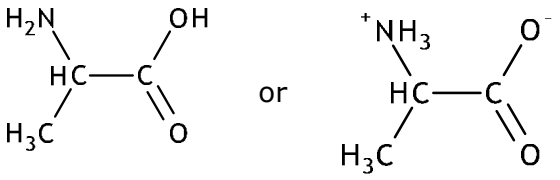
<table>
<tr><th>Question Number</th><th>Acceptable Answers</th><th>Reject</th><th>Mark</th></tr>
<tr><td>23(a)</td><td>
<table>
<tr><th>Element</th><th>%</th><th></th><th>mol</th><th>Ratio</th></tr>
<tr><td>C</td><td>40.44</td><td>÷12</td><td>= 3.37</td><td>2.999</td></tr>
<tr><td>H</td><td>7.87</td><td>÷ 1</td><td>= 7.87</td><td>7.004</td></tr>
<tr><td>O</td><td>35.96</td><td>÷ 16</td><td>= 2.2475</td><td>2.000</td></tr>
<tr><td>N</td><td>15.73</td><td>÷ 14</td><td>= 1.12357</td><td>1.000</td></tr>
<tr><td></td><td></td><td></td><td>(1)</td><td>(1)</td></tr>
</table>
Empirical formula = $C_3H_7O_2N$ (1)
Symbols in any order
Stand alone mark
No TE on incorrect ratio
IGNORE significant figure and rounding errors except 1sf in mole calculation
</td><td></td><td>3</td></tr>
</table>

Question Number	Acceptable Answers	Reject	Mark
23(b)(i)	Peak at *m/e* = 89 labelled M^+ ALLOW Any clear label e.g. $C_3H_7O_2N^+$		1

Question Number	Acceptable Answers	Reject	Mark
23(b)(ii)	M_r = 89 = M_r ($C_3H_7O_2N$) so molecular formula is $C_3H_7O_2N$ Symbols in any order IGNORE structural and displayed formulae	Answer with no explanation M_r = 90 $C_3H_7O_2N^+$	1

Question Number	Acceptable Answers	Reject	Mark
23(c)(i)	Gas evolved is carbon dioxide / CO_2 (1) (so carboxylic) acid / -COOH group is present (1) Dark blue colour indicates the formation of a (copper(II)) complex ALLOW indicates ligand exchange has occurred (1) Suggests that an amine / $-NH_2$ group is present ALLOW NH (1) IGNORE ammine amino acid	NH_3 complexes Amide group	4

Question Number	Acceptable Answers	Reject	Mark
23(c)(ii)	Any 2 of A, B, C or D (1 mark for each) <u>Molecules</u> A  B  C  D  <u>Zwitterions</u> A  B  C  D  Or fully displayed structures		2

Question Number	Acceptable Answers	Reject	Mark
23(c)(iii)	First mark P has structure A  Second mark EITHER Splitting pattern quartet due to CH next to CH_3 and doublet due to CH_3 next to CH ALLOW A comparison e.g A has quartet & doublet but B has two triplets OR As the areas / heights of the two peaks are in a 3:1 ratio (approximately), there must be 3 protons in one environment and 1 in another No TE if A is not one of the isomers given in (c)(ii)	Just quartet & doublet Just two peaks	2

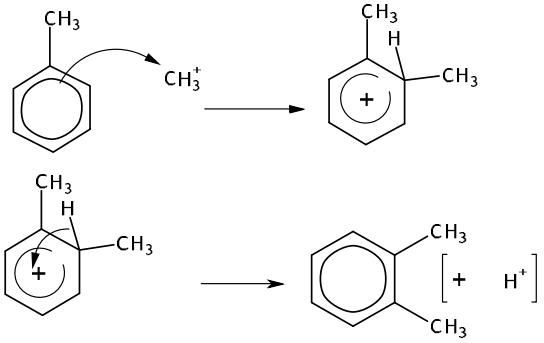
Question Number	Acceptable Answers	Reject	Mark
23(d)	P (is an amino acid) exists as a zwitterion ALLOW Zwitterion formula OR molecules are held together by (strong) ionic forces IGNORE Just 'electrostatic forces'		1

Total for Question 23 = 14 marks
Total for Section B = 50 mark

Section C

Question Number	Acceptable Answers	Reject	Mark
24(a)(i)	M = chloro- /bromo- / iodo- methane / CH_3Cl / CH_3Br / CH_3I		1

Question Number	Acceptable Answers	Reject	Mark
24(a)(ii)	$CH_3X + AlCl_3 \rightarrow CH_3^+ + AlXCl_3^-$ Ignore curly arrows even if incorrect Ignore state symbols even if incorrect		1

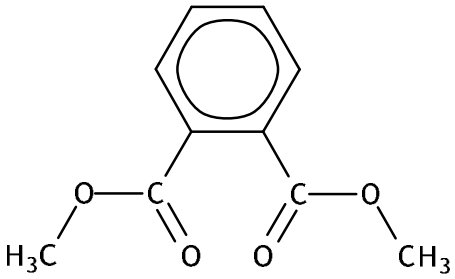
Ques. No.	Acceptable Answers	Reject	Mark
24(a)(iii)	 TE on incorrect electrophile in (a)(ii) If benzene used instead of methylbenzene OR If final product not 1,2-dimethylbenzene (max 2) Curly arrow from on or within the circle to positively charged carbon ALLOW Curly arrow from anywhere within the hexagon Arrow to any part of the CH_3^+ including to the + charge (1) Intermediate structure including charge with horseshoe covering at least 3 carbon atoms, and facing the tetrahedral carbon and some part of the positive charge must be within the horseshoe (1) Curly arrow from C—H bond to anywhere in the benzene ring reforming delocalized structure (1) Correct Kekulé structures score full marks Ignore any involvement of AlX_4^- in the final step	Curly arrow on or outside the hexagon Dotted bonds to H and CH_3	3

Question Number	Acceptable Answers	Reject	Mark
24(a)(iv)	The methyl group donates / pushes electrons into the benzene ring (because of its positive inductive effect / donating inductive effect) (1) (Increased electron density) makes the ring more susceptible to electrophilic attack (1) IGNORE Activating group / ring activation	Mention of lone pair Just 'reacts faster'	2

Question Number	Acceptable Answers	Reject	Mark
24(a)(v)	Any identified (name or formula) strong mineral acid: sulfuric acid / H_2SO_4(aq) / hydrochloric acid / HCl(aq) / nitric acid / HNO_3(aq) ALLOW Formulae without (aq) concentrated (acid) IGNORE dilute 'acid' H^+(aq) / H^+ addition of extra alkali before adding acid		1

Question Number	Acceptable Answers	Reject	Mark
24(b)(i)	Oxidation state / oxidation number /valency easily changed ALLOW 'Just' variable oxidation state / oxidation number /valency OR easily oxidized and reduced IGNORE references to d orbitals / active sites		1

Question Number	Acceptable Answers	Reject	Mark
24(b)(ii)	Surface area of catalyst decreases OR Number of active sites is reduced ALLOW Active sites blocked OR Catalyst is poisoned	Active sites saturated / occupied by reactants denatured	1

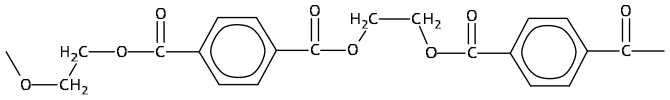
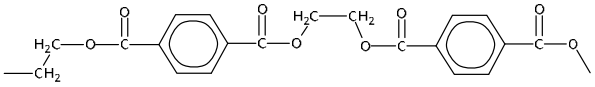
Question Number	Acceptable Answers	Reject	Mark
24(c)(i)	 ALLOW $COOCH_3$ for ester group skeletal / displayed structures omission of benzene ring circle.		1

Question Number	Acceptable Answers	Reject	Mark
24(c)(ii)	The forces between plasticiser / phthalate and polymer molecules are weak (1) So London /dispersion /van der Waals forces (rather than covalent bonds) ALLOW dipole-dipole forces OR Forces between water and plasticiser / phthalate molecules are strong(er) / hydrogen bonds (1)	hydrogen bonds	2

Question Number	Acceptable Answers	Reject	Mark
24(c)(iii)	Any two of The intermolecular forces between the plasticiser and the polymer molecules are weaker than the those between polymer molecules (1) The polymer molecules move over one another more easily (1) Plasticiser molecules disrupt the polymer structure (1)	break cross-linking between polymer molecules / (covalent) bonds	2

Question Number	Acceptable Answers	Reject	Mark
24(d)(i)	PCl_5 / phosphorus(V) chloride / phosphorus pentachloride OR PCl_3 / phosphorus(III) chloride / phosphorus trichloride OR $SOCl_2$ / thionyl chloride / thionyl dichloride		1

Question Number	Acceptable Answers	Reject	Mark
24(d)(ii)	Reaction goes to completion / (much) faster / not reversible / not an equilibrium / higher yield / catalyst not needed / uses less energy ALLOW Heat / increased temperature not required. Reverse arguments. IGNORE Cost / reacts easily. More reactive.		1

Question Number	Acceptable Answers	Reject	Mark
24(d)(iii)	 OR  ALLOW $-COOCH_2CH_2OOC-$ for diester link three ester links (i.e. – CO-O-CH_2-) only if polymer is open-chained (non-cyclic) and at least a dimer (1) remaining structure (1) this mark is not stand alone IGNORE $()_n$	Omission of benzene ring circle	2

Question Number	Acceptable Answers	Reject	Mark
24(d)(iv)	Methanol / CH_3OH	alcohol	1

Total for Question 24 = 20 marks
Total for Section C = 20 marks

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