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Mark Scheme (Results)

January 2013

GCE Chemistry (6CH05) Paper 01

General Principles of Chemistry II
Transition Metals and Organic Chemistry

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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.
- 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(a)	C		**1**
(b)	A		**1**

Question Number	Correct Answer	Reject	Mark
2(a)	C		**1**
(b)	A		**1**
(c)	B		**1**

Question Number	Acceptable Answers	Reject	Mark
3	C		**1**

Question Number	Acceptable Answers	Reject	Mark
4	C		**1**

Question Number	Acceptable Answers	Reject	Mark
5	B		**1**

Question Number	Correct Answer	Reject	Mark
6(a)	D		**1**
(b)	C		**1**
(c)	A		**1**

Question Number	Correct Answer	Reject	Mark
7	B		**1**

Question Number	Acceptable Answers	Reject	Mark
8	C		**1**

Question Number	Acceptable Answers	Reject	Mark
9	B		**1**

Question Number	Acceptable Answers	Reject	Mark
10	C		**1**

Question Number	Acceptable Answers	Reject	Mark
11	D		**1**

Question Number	Acceptable Answers	Reject	Mark
12	A		**1**

Question Number	Acceptable Answers	Reject	Mark
13(a)	D		**1**
(b)	B		**1**
(c)	A		**1**

TOTAL FOR SECTION = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
14 (a)	**A** = copper(II) hydroxide / $Cu(OH)_2$ / $Cu(OH)_2(H_2O)_4$ **(1)** **B** = copper(II) oxide / CuO **(1)** **C** = tetraamminecopper(II) / $Cu(NH_3)_4^{2+}$ / $Cu(NH_3)_4(H_2O)_2^{2+}$ ALLOW $Cu(NH_3)_6^{2+}$ / hexaamminecopper(II) **(1)** **D** = copper / Cu / copper(0) / Cu(0) **(1)** **E** = copper(II) sulfate / $CuSO_4$ / Cu^{2+} / $Cu(H_2O)_6^{2+}$ **(1)** **F** = diamminecopper(I) / $Cu(NH_3)_2^{+}$ **(1)** ALLOW coordination numbers 1-6 in **F** Oxidation number separate from name IGNORE state symbols even if incorrect names without oxidation numbers except for **D**	Formulae with incomplete or unbalanced charges Incorrect oxidation states even with correct formulae	**6**

Question Number	Acceptable Answers	Reject	Mark
14 (b)	(Dilute) sulfuric acid / H_2SO_4 / $H_2SO_4(aq)$ ALLOW concentrated		**1**

Question Number	Acceptable Answers	Reject	Mark
14 (c)(i)	(transition metal / d-block element) complex(es) /complex ion(s) IGNORE ammines	Complex molecules amines, ions, ligands	**1**

Question Number	Acceptable Answers	Reject	Mark
14 (c)(ii)	Copper ion in **C** has partially filled **d** orbital(s) / subshell / $3d^9$ ALLOW unpaired d electron d shell **(1)** Copper ion in **F** has (completely) filled **d** orbitals / subshell / $3d^{10}$ **(1)** Reference to complete / incomplete d orbitals **max 1** EITHER Electronic **transitions** between partially filled (d) orbitals (of different energy) are possible OR Electronic **transitions** between (completely) filled (d) orbitals (of different energy) are not possible **(1)** ALLOW Equivalent words for transition e.g. promotion / jump / movement Penalise use of just 'shell' once IGNORE references to electrons returning to lower energy levels and emission of light	d orbitals empty no unpaired electrons (in F) orbital (singular) Splitting impossible because d orbitals full	**3**

Question Number	Acceptable Answers	Reject	Mark
14 (c)(iii)	Copper(I) is **oxidized** (to copper(II)) ALLOW **F** / it is **oxidized** **(1)** By oxygen / air **(1)** Second mark depends on first IGNORE 'shaking'		**2**

Question Number	Acceptable Answers	Reject	Mark
14 (d)(i)	(simultaneous) oxidation and reduction **(1)** OR Simultaneous increase or decrease in oxidation number of an element **(1)** ALLOW 'Species' 'atoms of the same type' for 'element' Explanation in terms of copper(I) IGNORE Atom / ion / compound / substance / reactant	molecule	**2**

Question Number	Acceptable Answers	Reject	Mark
14 (d)(ii)	$2Cu^+ \rightarrow Cu + Cu^{2+}$ OR $2CuI + 2H^+ \rightarrow Cu + Cu^{2+} + 2HI$ OR $2CuI \rightarrow Cu + Cu^{2+} + 2I^-$ IGNORE state symbols even if incorrect	Non-ionic equations	**1**

Question Number	Acceptable Answers	Reject	Mark
14 (d)(iii)	ALLOW The use of cell notation (as in the Data Booklet SEP table) in place of equations e.g. $Cu^+(aq) \mid Cu(s)$ $E^\ominus = +0.52$ (V) (from the data book the equations are) $Cu^+(aq) + e^- \rightarrow Cu(s)$ $E^\ominus = +0.52$ (V) $Cu^{2+}(aq) + e^- \rightarrow Cu^+(aq)$ $E^\ominus = +0.15$ (V) **(1)** So $E^\ominus_{cell} = 0.52 - 0.15 = +0.37$ (V) **(1)** Correct answer including sign with no working scores full marks TE for second mark for use of $Cu^{2+}ICu$ +0.34 (V) which gives +0.19(V)/+0.18(V) No TE on incorrect equation in (d)(ii)	**Answer** without + sign	**2**

Question Number	Acceptable Answers	Reject	Mark
14 (d)(iv)	ALLOW In both schemes the use of cell notation (as in the Data Booklet SEP table) in place of equations e.g. $Cu^{2+}(aq) \mid Cu(s)$ $E^{\ominus} = +0.34$ (V) Penalise omission of electrons from equations and vertical lines from cell diagrams and reversal of equation without reversing sign. once only IGNORE omission of + sign for all $E^{\ominus}$ values **Scheme 1 (oxidation of copper)** Copper (formed (by disproportionation)) is oxidized (by nitric acid) must be stated in words stand alone mark **(1)** Relevant half equations are $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ $E^{\ominus} = +0.34$ (V) **(1)** $2NO_3^-(aq) + 4H^+(aq) + 2e^- \rightarrow N_2O_4(g) + 2H_2O(l)$ $E^{\ominus} = +0.80$ (V) OR $NO_3^-(aq) + 3H^+(aq) + 2e^- \rightarrow HNO_2(aq) + H_2O(l)$ $E^{\ominus} = +0.94$ (V) **(1)** Correct overall equation scores both marks: $Cu + 2\ NO_3^- + 4H^+ \rightarrow Cu^{2+} + N_2O_4 + 2H_2O$ OR $Cu + NO_3^- + 3H^+ \rightarrow Cu^{2+} + HNO_2 + H_2O$ So $E^{\ominus}_{cell}$ is +0.46 (V) (or +0.60 (V) or just 'positive') **(1)** **Scheme 2 (oxidation of copper(I))** Copper(I) iodide / Cu^+ is oxidized (by nitric acid) must be stated in words **(1)** stand alone mark $Cu^{2+}(aq) + e^- \rightarrow Cu^+(aq)$ $E^{\ominus} = +0.15$ (V) **(1)** $2NO_3^-(aq) + 4H^+(aq) + 2e^- \rightarrow N_2O_4(g) + 2H_2O(l)$ $E^{\ominus} = +0.80$ (V) OR $NO_3^-(aq) + 3H^+(aq) + 2e^- \rightarrow HNO_2(aq) + H_2O(l)$ $E^{\ominus} = +0.94$ (V) **(1)** Correct overall equation scores both marks:		**4**

	$2Cu^+ + 2NO_3^- + 4H^+ \rightarrow 2Cu^{2+} + N_2O_4 + 2H_2O$ $2Cu^+ + NO_3^- + 3H^+ \rightarrow 2Cu^{2+} + HNO_2 + H_2O$ So $E^{\ominus}_{cell}$ is +0.65 (V) (or +0.79 (V) or just 'positive') **(1)** IGNORE (omission of) state symbols even if incorrect		

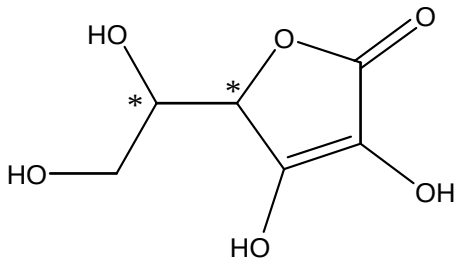
Total for Q14 = 22 Marks

Question Number	Acceptable Answers	Reject	Mark
15 (a)(i)	(vitamin C / ascorbic acid) oxidation / oxidized / oxidised ALLOW oxidisation	Redox / oxidation-reduction / reduction-oxidation	**1**

Question Number	Acceptable Answers	Reject	Mark
15 (a)(ii)	(very) pale yellow / straw coloured **(1)** IGNORE 'just before the end-point' blue-black to colourless (both needed) **(1)** Accept (dark) blue or black ALLOW pale yellow / straw coloured to colourless for 1/2	Just 'yellow' Clear	**2**

Question Number	Acceptable Answers	Reject	Mark
15 (a)(iii)	Moles $S_2O_3^{2-}$ = 27.85 x 10^{-3} x 0.0631 **(1)** (= 1.757335 x 10^{-3}) moles of I_2 remaining = Moles $S_2O_3^{2-}$ ÷ 2 = 27.85 x 10^{-3} x 0.0631 ÷ 2 = 8.786675 x 10^{-4} = 8.79 x 10^{-4} **(1)** Moles ascorbic acid = moles I_2 at start − moles I_2 remaining = 2.00 x 10^{-3} − 8.786675 x 10^{-4} = 1.1213325 x 10^{-3} = 1.12 x 10^{-3} **(1)** M_r (ascorbic acid) = 176 Mass ascorbic acid in 250 cm^3 = 10 x M_r x moles ascorbic acid = 10 x 176 x 1.1213325 x 10^{-3} **(1)** (= 1.97355) Percentage ascorbic acid in tablet 100 x mass ascorbic acid in 250 cm^3 ÷ 2 = 100 x 10 x 176 x 1.1213325 x 10^{-3} ÷ 2 = 98.67726 = 98.7% **(1)** IGNORE SF except 1 SF Premature rounding gives 98.5% (5) Correct answer with no working scores full marks TE at each stage of the calculation.	Answers greater than 100%	**5**

Question Number	Acceptable Answers	Reject	Mark
15(a)(iv)	EITHER Using larger **mass** reduces the percentage error / uncertainty (in weighing) OR Using larger amount reduces the percentage error / uncertainty in **weighing** OR Reverse discussion of two tablets ALLOW using four tablets gives a more representative sample	Just 'reduces the percentage error' Titration value will be larger (with four tablets) so reduces the percentage error (in volume measurement)	**1**

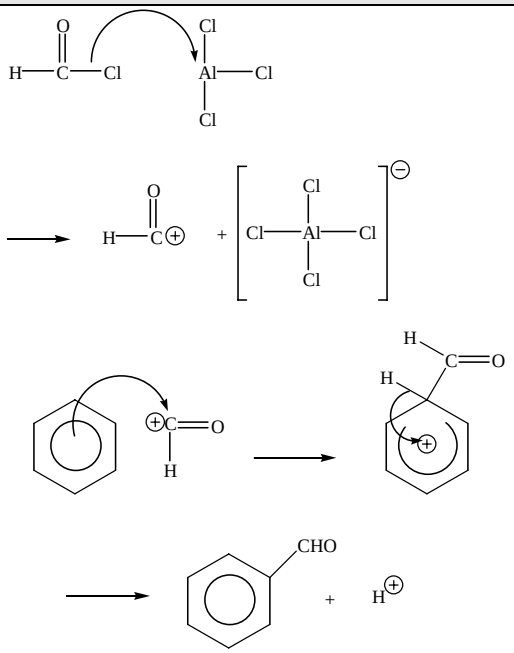
Question Number	Acceptable Answers	Reject	Mark
15 (b)(i)	 **(2)** Mark independently ALLOW any clear indication of chiral centres		**2**

Question Number	Acceptable Answers	Reject	Mark
15 (b)(ii)	**First mark** Use of (plane-)polarized light (mentioned somewhere) **(1)** ALLOW Use a polarimeter **Second mark** Pure optical isomer / enantiomer) **rotates** the **plane** of (plane-) polarized light OR racemic mixture has no effect on the **plane** of (plane-) polarized light **(1)** IGNORE optically active / inactive ALLOW rotates plane-polarized light scores 2		**2**

Question Number	Acceptable Answers	Reject	Mark
15(b)(iii)	(Ester group / vitamin C / it) is hydrolysed ALLOW Vitamin C is oxidized Ester / vitamin C is broken down to form carboxylic acid **and** alcohol (groups) IGNORE Just 'breaks down'	C=O is broken Just 'oxidation'	1

Total for Q15 = 14 Marks

Question Number	Acceptable Answers	Reject	Mark
16(a)(i)	The delocalization of the (π) electrons of the ring make benzene more stable (than 1,3,5-cyclohexatriene) **(1)** IGNORE bonding in benzene is strong Substitution retains this (stable) arrangement OR Addition removes this (stable) arrangement **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
16(a)(ii)	 Formation of electrophile (curly arrow, structural formulae not required). Positive charge may be anywhere on the electrophile ALLOW HCl + CO for HCOCl ALLOW Non-displayed electrophile **(1)** Curly arrow from benzene ring to electrophile **(1)** Wheland structure with gap opposite tetrahedral carbon **(1)** Curly arrow from C—H bond into ring and formation of **correct** organic product OR Kekulé structures **(1)** IGNORE Use of $AlCl_4^-$ to pick off proton Proton product First curly arrow may come from any part of the delocalisation circle Second curly arrow may come from any part of the C–H bond Positive charge on the Wheland structure may be in any part of the horseshoe	-COH /-HCO Positive charge on the tetrahedral carbon	**4**

Question Number	Acceptable Answers	Reject	Mark
16(a)(iii)	In each step the second mark is dependent on the first **Step 2** Potassium dichromate((VI)) / $K_2Cr_2O_7$ / sodium dichromate((VI)) / $Na_2Cr_2O_7$ ALLOW Potassium manganate ((VII)) / $KMnO_4$ Sodium manganate ((VII)) / $NaMnO_4$ **(1)** Stand alone mark Sulfuric acid / H_2SO_4 (ALLOW nitric acid) **(1)** Ignore 'concentrated' ALLOW Acidified potassium (/ sodium) dichromate((VI)) OR Acid and potassium (/ sodium) dichromate((VI)) **(2)** $Cr_2O_7^{2-}$ and H^+ OR acidified dichromate((VI)) **(1)** **Step 3** Lithium tetrahydridoaluminate((III)) / $LiAlH_4$ OR Lithium aluminium hydride **(1)** Stand alone mark (Dry) ether / ethoxyethane / (di)ethyl ether **(1)** Sodium borohydride / $NaBH_4$ in ethanol, alkali or water scores 1/2 **(1)**	Incorrect oxidation number Hydrochloric acid Hydrogen and catalyst / Tin and HCl	**4**

Question Number	Acceptable Answers	Reject	Mark
16(b)	**Marking Point 1** Electron density of the ring increased **(1)** Stand alone mark **Marking Point 2** Due to donation of oxygen / OH group lone pair to the ring **(1)** **Marking Point 3 and 4** Any two from in phenol oxygen / OH group attached directly to ring Oxygen / OH group in phenylmethanol too far away / not attached directly to ring (In phenol) lone pair overlaps with the π electrons / delocalised electrons (of the ring) ALLOW p orbital for lone pair for this mark **(2)**		**4**

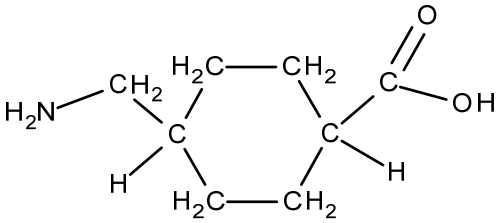
Total for Q16 = 14 Marks

TOTAL FOR SECTION B = 50

Section C

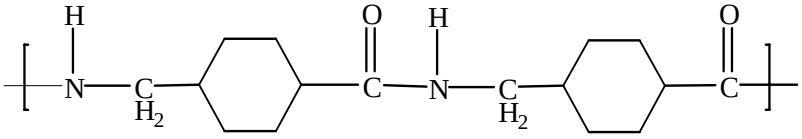
Question Number	Acceptable Answers	Reject	Mark
17(a)(i)	There is a barrier to rotation about a (C=C) bond **(1)** ALLOW restricted / limited / no rotation Each carbon atom (in the C=C double bond) has (two) different atoms / groups attached **(1)** IGNORE reference to priority groups	Just 'molecule cannot rotate'	**2**

Question Number	Acceptable Answers	Reject	Mark
17(a)(ii)	There is a barrier to / restricted rotation about the ring OR The ring behaves like a double bond	Reference to benzene ring Just 'molecule cannot rotate'	**1**

Question Number	Acceptable Answers	Reject	Mark
17(a)(iii)	 Any diagram of the correct molecule showing the groups (attached to the ring) on same side of the ring OR zwitterion ALLOW Amine group in skeletal form	Omission of amine CH_2	**1**

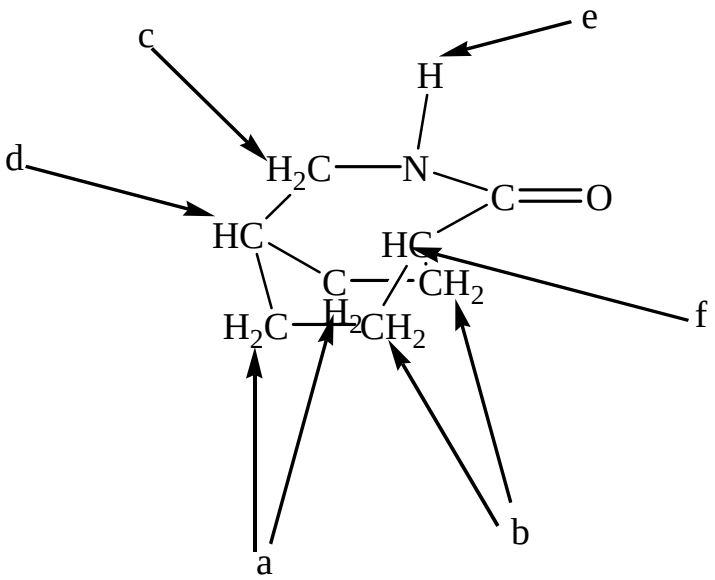
Question Number	Acceptable Answers	Reject	Mark
17(a)(iv)	Tranexamic acid exists as a zwitterion OR Diagram of zwitterion OR Description of zwitterion formation **(1)** So the (strongest) intermolecular forces are ionic (strong) ALLOW electrostatic for ionic **(1)** IGNORE H bonding in tranexamic acid if **either** of the first two marks scored. Otherwise... Hydrogen bonding in tranexamic acid scores 1/2 max Undecane has (only) (much weaker) London / dispersion / van der Waals / temporary induced dipole (-induced dipole) forces / interactions **(1)**		**3**

Question Number	Acceptable Answers	Reject	Mark
17(b)(i)	Phosphorus(v) chloride / PCl_5 ALLOW phosphorus pentachloride / phosphorus(III) chloride / PCl_3 / phosphorus trichloride Thionyl chloride (sulfur dichloride oxide) / $SOCl_2$	HCl	**1**

Question Number	Acceptable Answers	Reject	Mark
17(b)(ii)	 **First mark** amide linkage ALLOW CONH for amide linkage **(1)** **Second mark** Completion of structure (brackets not required) with displayed or skeletal formula **(1)** Second mark dependent on first Dimer scores amide linkage mark only		**2**

Question Number	Acceptable Answers	Reject	Mark
17(b)(iii)	Condensation / addition-elimination (polymerization)	Addition (polymerization) Elimination (polymerization) Polyamide formation	**1**

Question Number	Acceptable Answers	Reject	Mark
17(b)(iv)	Protein / proteins / polypeptide / polypeptides / peptide / peptides ALLOW Enzyme / Enzymes	Nylon Polyamide amino acids	1

Question Number	Acceptable Answers	Reject	Mark
17(c)(i)	Check sequence of letters. Candidates may have labelled the groups of hydrogen atoms with different letters, which is fine. **First mark** Unique N**H** (at e) **(1)** **Second mark** **(1)** Unique C**H**$_2$ (at c) **Third mark** **(1)** C**H** (at d) and C**H** (at f) with different unique labels **Fourth mark** **(1)** 2C**H**$_2$ (at a) and 2C**H**$_2$ (at b) with different new labels  		4

Question Number	Acceptable Answers	Reject	Mark
17(c)(ii)	C═O amide (stretching vibrations are in the region) 1700-1630 cm^{-1} **(1)** N—H amide (stretching vibrations are in the region) 3500-3140 cm^{-1} **(1)** Amide only needs to be mentioned once but... These answers without mention of **amide** max 1 Amides have peaks in these regions max 1	Ketone Amine (for amide)	2

Question Number	Acceptable Answers	Reject	Mark
17(c)(iii)	**Any two from** In the trans isomer the (amine and acid chloride) groups are too far apart to react intramolecularly / to form **M** OR Because the groups are on opposite sides of the (plane of the) **ring** OR More likely to polymerize / react with adjacent molecules. **(2)** Marks may also be scored by a reverse argument: In the cis isomer the (amine and acid chloride) groups are on the same side of the (plane of the) **ring** **(1)** So close enough to react intramolecularly / to form **M (1)**	bond	2

Total for Q17 = 20 Marks

TOTAL FOR SECTION C = 20 MARKS

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