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Mark Scheme (Results)

Summer 2015

GCE Chemistry (6CH05/01)

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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

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Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	C		1

Question Number	Correct Answer	Reject	Mark
2	A		1

Question Number	Correct Answer	Reject	Mark
3	C		1

Question Number	Correct Answer	Reject	Mark
4	B		1

Question Number	Correct Answer	Reject	Mark
5	C		1

Question Number	Correct Answer	Reject	Mark
6	B		1

Question Number	Correct Answer	Reject	Mark
7	B		1

Question Number	Correct Answer	Reject	Mark
8	D		1

Question Number	Correct Answer	Reject	Mark
9	C		1

Question Number	Correct Answer	Reject	Mark
10	D		1

Question Number	Correct Answer	Reject	Mark
11	C		1

Question Number	Correct Answer	Reject	Mark
12	A		1

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Question Number	Correct Answer	Reject	Mark
13	D		1

Question Number	Correct Answer	Reject	Mark
14	D		1

Question Number	Correct Answer	Reject	Mark
15	A		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	B		1

Question Number	Correct Answer	Reject	Mark
20	B		1

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Section B

Question Number	Acceptable Answers	Reject	Mark
21a(i)	Ni: $(1s^2\ 2s^2 2p^6)\ 3s^2 3p^6\ 3d^8\ 4s^2$ (1) Cu: $(1s^2\ 2s^2 2p^6)\ 3s^2 3p^6\ 3d^{10} 4s^1$ (1) ALLOW capital letters, subscripts for superscripts ALLOW 4s before 3d Penalise omission of $3s^2 3p^6$ once only if rest is correct		2

Question Number	Acceptable Answers	Reject	Mark
21a*(ii)	First electron removed is from **4s** (in both atoms) (1) Second electron in Cu (is harder to remove so it is) EITHER closer to nucleus/in inner shell OR less shielded (1) IGNORE Comments about second electron being in full shell/ in a 3d shell/in a 3d orbital Reference to $3d^{10}$ stability		2

Question Number	Acceptable Answers	Reject	Mark
21a(iii)	(attraction on (3d) electrons increases due to) number of protons increasing / nuclear charge increasing IGNORE The charge density of the 2^+ ions increases Effective nuclear charge		1

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Question Number	Acceptable Answers	Reject	Mark
21b(i)	$2Cu^{+}(aq) \rightarrow Cu(s) + Cu^{2+}(aq)$ IGNORE Eqm sign for $\rightarrow$	Reverse equation Any equation involving electrons	1

Question Number	Acceptable Answers	Reject	Mark
21b(ii)	Both white ALLOW (both) Colourless (1) COMMENT Ignore states eg solution/precipitate As have $3d^{10}$ / have a full 3d sub-shell /**ALL** 3d orbitals are full (1) IGNORE Does not have partially filled d orbitals They do not absorb light No d-d transitions occur		2

Question Number	Acceptable Answers	Reject	Mark
21c	(Zinc) does not form a (stable) **ion** with incompletely/partially filled d orbitals ALLOW d sub-shell for d orbitals The only (stable) **ion** formed by zinc has full d sub-shell It does not form a (stable) oxidation state with incompletely/partially filled d orbitals	Element has full d shells.	1

Total for Question 21 = 9 marks

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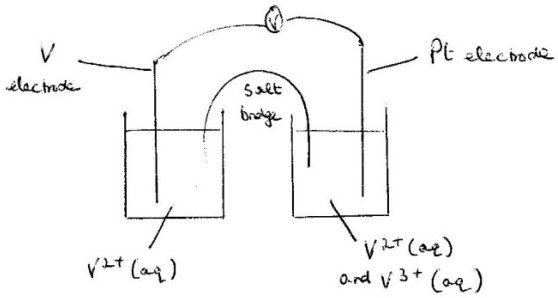
Question Number	Acceptable Answers	Reject	Mark
22(a)(i)			3
	Beaker with V electrode in solution containing V^{2+}(aq) AND beaker containing V^{2+}(aq) and V^{3+}(aq) with Pt electrode N.B. Both solution levels must be shown (1)		
	Labelled salt bridge AND connections to voltmeter ALLOW Suitable name or formula of salt for label	Salt bridge neither dipping into nor touching solution unless penalised in MP1	
	ALLOW Salts eg NaCl in salt bridge (1)	Salt bridge containing an alkali/acid	
	Ion concentrations = 1 mol dm^{-3} ALLOW M for mol dm^{-3} Concentrations given in one beaker only (1)	1 mole of V^{2+} and 1 mole of V^{3+}	
	Beaker positions may be reversed Ignore references to temperature and pressure		

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Question Number	Acceptable Answers	Reject	Mark
22(a)(ii)	**First mark** $2V^{3+} + V \rightarrow 3V^{2+}$ Balanced equation, either direction ALLOW Eqm sign for $\rightarrow$ IGNORE State symbol even if incorrect (1) **Second mark** Correct direction ALLOW If balancing is incorrect or e^- included in equation (1)	e^- included	2

Question Number	Acceptable Answers		Reject	Mark
22b(i)	$([VO^{2+}(aq) + 2H^+(aq)], [V^{3+}(aq) + H_2O(l)] \mid Pt)$	+0.34		1
	$([VO_2^+(aq) + 2H^+(aq)], [VO^{2+}(aq) + H_2O(l)] \mid Pt)$	+1.00		
	Sign and value needed			

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Question Number	Acceptable Answers	Reject	Mark
22(b)(ii)	**A:** (+)0.32 (V) (1) VO^{2+} (may be shown as a product in an overall equation) (1) EITHER Bubbles / effervescence (of colourless gas) OR Colour changes (from yellow) to blue TE on negative E_{cell} for 'stays yellow' ALLOW (from yellow) to green if justified by partial reduction (1) **B:** −0.2(0) (V) (1) no change / stays blue (1) If B=+0.2 or other positive value allow colour change from blue to green or brown. EITHER Consistent use of rule that reaction occurs when E_{cell} is positive OR Consistent use of rule that no reaction occurs when E_{cell} negative ALLOW If implied but not stated specifically (1)	Violet Stays violet	6

Question Number	Acceptable Answers	Reject	Mark
22c(i)	$V^{2+} + 2H_2O \rightarrow VO_2^+ + 4H^+ + 3e^-$ OR Ox number of V increases by 3, ox number of Mn decreases by 5 ALLOW Balanced full equation $5V^{2+} + 3MnO_4^- + 4H^+ \rightarrow$ $5VO_2^+ + 3Mn^{2+} + + 2H_2O$	Reverse equation unless used to deduce final correct equation.	1

Question Number	Acceptable Answers	Reject	Mark
22(c)(ii)	(35.50 x 0.0200/1000) = $7.1(0) \times 10^{-4}$ / 0.00071		1

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Question Number	Acceptable Answers	Reject	Mark
22(c)(iii)	**In final answer** **92.2 scores 3 marks** **33.2 scores 2 marks** (ratio inverted) **55.3 scores 2 marks** (ratio 1:1) METHOD 1 Mol V^{2+} reacting = $7.10 \times 10^{-4} \times 5/3$ $=$**1.18333×10^{-3}** = mol VO_2^+ TE on answer to (c)(ii) (1) Mass NH_4VO_3 = $(1.183 \times 10^{-3} \times 116.9)$ = **0.1382927** g TE from 4.26×10^{-3} =0.497994 (1) % purity = (0.1382927x 100/ 0.150) = (92.19333) = **92.2%** TE from 0.497994 = 33.2% (1) METHOD 2 If 100% pure, moles of NH_4VO_3 $=0.150/116.9=1.283 \times 10^{-3}$ (1) Mol V^{2+} reacting = $7.10 \times 10^{-4} \times 5/3$ $=$**1.18333×10^{-3}** = mol VO_2^+ TE on answer to (c)(ii) (1) % purity = $=1.18333 \times 10^{-3} \times 100/1.283 \times 10^{-3}$ = **92.2%** (1) ALLOW TE at each step provided that each number used is to at least 2sf	x 3/5 = 4.26×10^{-4}	3

Total for Question 22 = 17 marks

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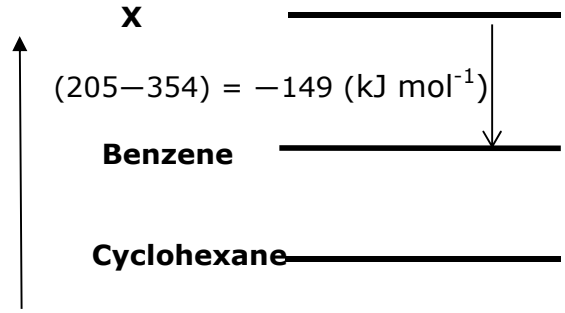
Question Number	Acceptable Answers	Reject	Mark
23(a)	All carbon to carbon bonds same length/ longer C-C and shorter C=C not present IGNORE Just "benzene has a delocalised ring" Benzene does not have C=C double bonds Any references to shape/ bond angles		1

Question Number	Acceptable Answers	Reject	Mark
23(b)(i)	(3 x -118) = -354 (kJ mol^{-1})		1

Question Number	Acceptable Answers	Reject	Mark
23(b)(ii)	 **First mark** Relative levels with names or formulae (1) **Second mark** Value —149 (kJ mol^{-1}) + arrow in correct direction ALLOW double-headed arrow (1) TE from value in (b)(ii) IGNORE $3H_2$ if shown / cyclohexene / other arrows/values	Diagram inverted scores 0 +149	2

Question Number	Acceptable Answers	Reject	Mark
23(b)*(iii)	The p/pi-/Π/6 electrons (of carbon) (1) are delocalised in benzene (but not in **X**) (1)		2

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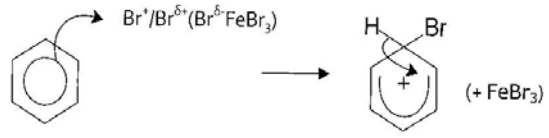
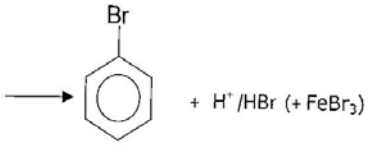
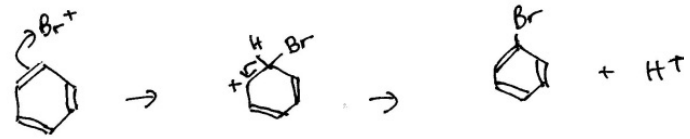
Question Number	Acceptable Answers	Reject	Mark
23(c)	**First mark:** $FeBr_3 + Br_2 \rightarrow FeBr_4^- + Br^+$ OR $Br\text{-}Br + FeBr_3 \rightarrow Br^{\delta+}\ldots.\ Br^{\delta-}FeBr_3$ (1) Ignore state symbols even if wrong **Second, third and fourth marks:** **Either**   Arrow from benzene ring electrons (from **inside** the hexagon) to **Br^+ / $Br^{\delta+}$** (….. $Br^{\delta-}FeBr_3$) (1) Correctly drawn intermediate with delocalisation covering at least three carbon atoms, but not the carbon atom bonded to the bromine , with the positive charge shown inside the horseshoe The bonds to H and Br may be dotted (1) Arrow from / close to C-H **bond** to inside the hexagon **and** H^+ / HBr as product (1) **OR**  Use of Kekulé structure for benzene and intermediate with arrow from C=C double bond to **Br^+ / $Br^{\delta+}$** (….. $Br^{\delta-}FeBr_3$) (1) Correctly drawn intermediate with + charge on the C atom next to the C bonded to H and Br	Gap in wrong place	4

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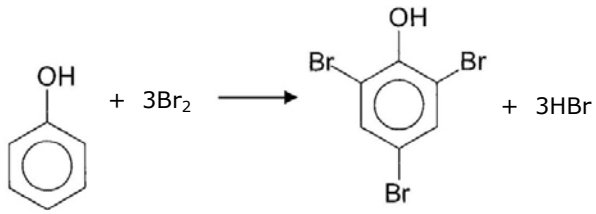
	The bonds to H and Br may be dotted (1) Arrow from / close to C-H **bond** to bond beside + charged C **and** H^+ / HBr as product (1) Each marking point is independent		

Question Number	Acceptable Answers	Reject	Mark
23(d)(i)	Bromine goes colourless OR It/the mixture goes from brown to colourless ALLOW Red-brown/ Orange/ yellow/ combinations of these colours Bromine is decolorised (1) White precipitate/solid forms / Steamy fumes (1) IGNORE Antiseptic smell Gets hot	Goes clear Red to colourless Bromine is discoloured Effervescence	2

Question Number	Acceptable Answers	Reject	Mark
23(d)(ii)	 Organic product with structure shown (1) Rest of equation correct ALLOW C_6H_5OH or Kekule for phenol (1) $C_6H_5OH + 3Br_2 \rightarrow C_6H_2Br_3OH + 3HBr$ Scores MP2 only Substitution of 1Br or 2Br in any position in balanced equation scores MP2 only.		2

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Question Number	Acceptable Answers	Reject	Mark
***23(d)(iii)**	**Lone pair of electrons on oxygen** (may be shown on a diagram) **and** EITHER overlaps with pi cloud OR Feeds into / donates into / interacts with benzene ring (1) Activating benzene ring / increasing electron density of ring / making attack by **electrophiles** easier (1) COMMENT 'Lone pair of electrons on oxygen increases electron density of ring' scores (2) ALLOW benzene becomes a better nucleophile for MP2	OH group overlaps Just 'making it more reactive'.	2

Total for Question 23 = 16 marks

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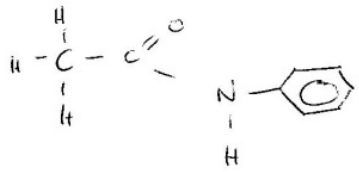
Question Number	Acceptable Answers	Reject	Mark
24(a)(i)	Concentrated nitric acid AND concentrated sulfuric acid ALLOW 'concentrated nitric and sulfuric acids' Concentrated HNO_3 and concentrated H_2SO_4	Extra reagents	1

Question Number	Acceptable Answers	Reject	Mark
24(a)(ii)	To prevent multiple substitutions/ to stop di- or trinitrobenzene forming ALLOW To stop further substitution (of NO_2)/ further nitration IGNORE further reaction	Further **addition** of nitro groups	1

Question Number	Acceptable Answers	Reject	Mark
24(a)(iii)	Tin/ Sn AND **concentrated** HCl/ **concentrated** hydrochloric acid ALLOW Iron/Fe or Zn/Zinc for tin Conc for concentrated	Dilute HCl	1

Question Number	Acceptable Answers	Reject	Mark
24(b)(i)	$C_6H_5NH_3^+Cl^-$ ALLOW $C_6H_5NH_3Cl$		1

Question Number	Acceptable Answers	Reject	Mark
24(b)(ii)	 ALLOW C_6H_5 for benzene Undisplayed CH_3	Skeletal formula Structural formula	1

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Question Number	Acceptable Answers	Reject	Mark
24(b)(iii)	**D** (transition metal) complex ion ALLOW Transition metal complex / copper complex IGNORE Formulae of ions (1) **F** (azo) dye / azo compound / diazo compound ALLOW diazonium compound molecule for compound (1)		2

Question Number	Acceptable Answers	Reject	Mark
24b(iv)	Benzenediazonium chloride ALLOW Phenyldiazonium chloride	Benzadiazonium chloride Diazonium salt	1

Question Number	Acceptable Answers	Reject	Mark
24b(v)	$HCl + NaNO_2$ OR Hydrochloric acid + Sodium nitrite / nitrate(III) OR alternative cation to Na^+ IGNORE HNO_2 Concentration of HCl	$HCl + HNO_2$	1

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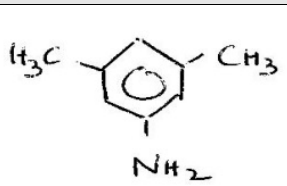
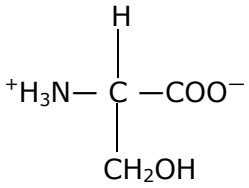
Question Number	Acceptable Answers	Reject	Mark
24b(vi)	 ALLOW any substitution positions $C_6H_{\mathbf{3}}(CH_3)_2NH_2$ H- $C_6H_{\mathbf{2}}(CH_3)_2NH_2$ Kekule structure	$C_6H_{\mathbf{2}}(CH_3)_2NH_2$	1

Total for Question 24 = 10 marks

Question Number	Acceptable Answers	Reject	Mark
25(a)(i)	 OR $HOCH_2CH(NH_3^+)CO_2^-$ ALLOW Charge on NH_3 shown on N atom		1

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Question Number	Acceptable Answers	Reject	Mark
***25(a)(ii)**	**EITHER** At pH 5.68 both NH_2 groups on lysine will be NH_3^+ / lysine has an overall positive charge while serine has no overall charge (1) So only lysine will move to negative terminal / in an electric field (1) **OR** lysine has a greater positive charge (than serine) (1) Lysine will move faster / further in an electric field (1) ALLOW They have different charges so will move different distances/ at different speeds 1 mark max IGNORE Answers based on molecular mass		2

Question Number	Acceptable Answers	Reject	Mark
***25(b)**	**COMMENT** Ignore references to H bonds from amino and carboxyl groups and assume that "phenylalanine cannot form H bonds" refers to R group in the compound. Serine has an OH (alcoholic) group which can form H bonds with water (1) Benzene ring in phenylalanine is bulky /is large and non-polar / is hydrophobic / London forces between phenylalanine molecules are significant ALLOW van der Waals etc for London ALLOW If MP1 is not scored, 'phenylalanine cannot form H bonds with water' can score MP2 (1)	VdW / id-id	2

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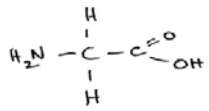
Question Number	Acceptable Answers	Reject	Mark
25(c)	H, -H, H- ALLOW $NH_2CH_2CO_2H$ / NH_2CH_2COOH 		1

Question Number	Acceptable Answers	Reject	Mark
25(d)(i)	(Measure) the amount of / angle of / degree of /extent of rotation (of plane of polarization/ plane polarized light) IGNORE direction they rotate the light	Just "polarimetry"	1

Question Number	Acceptable Answers	Reject	Mark
25(d)(ii)	(Leu has 1 chiral C but) Ile has 2 chiral C / 2 asymmetric C atoms OR The R group in Ile contains a chiral C (Leu has 2 optical isomers but Ile has 4 optical isomers) ALLOW Ile has (1) more chiral C (than leu) Chiral centres shown on formulae	Leu has no chiral C	1

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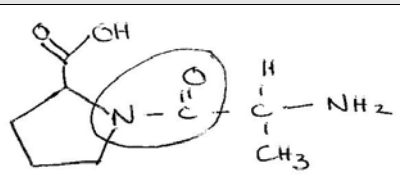
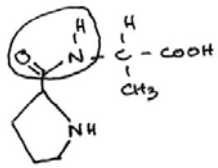
Question Number	Acceptable Answers	Reject	Mark
25(e)	 CON circled with N as part of ring (1) Fully correct structure (1) ALLOW -CH(CH_3)NH_2 shown skeletally **OR** Dipeptide using NH_2 from alanine and COOH from proline, with correct structure and CONH circled **This scores max (1)** 	Just N-C circled	2

Question Number	Acceptable Answers	Reject	Mark
25(f)(i)	CH_3CHO / CH_2CHOH ALLOW Displayed or semi-displayed formula C_2H_4O	CH_3COH (unless with correct structure)	1

Question Number	Acceptable Answers	Reject	Mark
25(f)(ii)	$C_{18}H_9NO_4$		1

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Question Number	Acceptable Answers	Reject	Mark
25(f)(iii)	**Several methods are possible.** **Amount of O should have been calculated and final answer should be consistent with masses/mols in calculation. There should be evidence of working at each stage for 4 marks** **MP1** 2.614 g CO_2 contain 0.7129 g C 0.2673 g H_2O contain 0.0297 g H OR 2.614 g CO_2 contain 0.059409 mol CO_2 0.2673 g H_2O contain 0.01485 mol H_2O (1) **MP2** Mass O in Q = (1.00 – 0.7129- 0.0297 -0.04620) = **0.2112** g (1) % mol/100g ratio C 71.29 5.94 18 H 2.97 2.97 9 N 4.62 0.33 1 O 21.12 1.32 4 **MP3** Number of moles of each element OR Number of mol in 100g Allow TE for incorrect mol of H – see calculation below (1) **MP4** Ratio stated must follow from numbers in calculation (so empirical formula is consistent with the molecular formula of **Q**) (1) **OR** **Calculation following error in H scores max (3)** If mass H is wrongly calculated as 0.01485 g, then mass O will be 0.22605 (TE for MP2) (1) % mol/100g ratio C 71.29 5.94 18 H 1.48 1.48 4.5 N 4.62 0.33 1 O 22.60 1.41 4.27		4

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	Number of moles of each element (TE for MP3) (1) Ratio stated and empirical formula said not to be consistent (TE for MP4) (1)		

Question Number	Acceptable Answers	Reject	Mark
25(f)(iv)	Mass of molecular ion in mass spectrum = 303 / any sensible fragment with mass eg 302 / 158 / 145 or smaller fragment (1) ALLOW Molecular ion based on formula in f(i) Number of peaks in nmr = 2 / 3 ALLOW 5 (1)	4	2

Total for Question 25 = 18 marks

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