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Mark Scheme (Results)

Summer 2016

Pearson Edexcel GCE
in Chemistry (6CH05) Paper 01
General Principles of Chemistry II

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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	B		**(1)**

Question Number	Correct Answer	Reject	Mark
2	C		**(1)**

Question Number	Correct Answer	Reject	Mark
3	A		**(1)**

Question Number	Correct Answer	Reject	Mark
4	D		**(1)**

Question Number	Correct Answer	Reject	Mark
5	B		**(1)**

Question Number	Correct Answer	Reject	Mark
6	D		**(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	C		**(1)**

Question Number	Correct Answer	Reject	Mark
11a	C		**(1)**

Question Number	Correct Answer	Reject	Mark
11b	D		**(1)**

Question Number	Correct Answer	Reject	Mark
12	B		**(1)**

Question Number	Correct Answer	Reject	Mark
13	D		**(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	B		**(1)**

Question Number	Correct Answer	Reject	Mark
17	A		**(1)**

Question Number	Correct Answer	Reject	Mark
18	D		**(1)**

Question Number	Correct Answer	Reject	Mark
19	A		**(1)**

Section B

Question Number	Acceptable Answers		Reject	Mark
20(a)	$V^{2+}(aq) + 2e^- \rightleftharpoons V(s)$	−1.18 (V)		**(1)**
	$V^{3+}(aq) + e^- \rightleftharpoons V^{2+}(aq)$	−0.26 (V)		
	Both correct			

Question Number	Acceptable Answers	Reject	Mark
20(b)(i)	**A** (salt bridge containing saturated solution of) potassium nitrate / KNO_3 ALLOW potassium chloride / KCl / sodium chloride / NaCl /sodium nitrate / $NaNO_3$ **(1)** **B** (electrode) platinum /Pt **(1)** **C** (solution containing) vanadium(II) **and** vanadium(III) ions / V^{2+} **and** V^{3+} ions ALLOW compounds of V^{2+} **and** V^{3+} **(1)** IGNORE any concentrations	KI / NaI vanadium	**(3)**

Question Number	Acceptable Answers	Reject	Mark
20(b)(ii)	298 K / 25°C (temperature) 1 atm / 100 kPa /101 kPa / 1 bar (pressure) ALLOW atmospheric pressure IGNORE hydrogen / gas 1 mol dm^{-3} (all concentrations) ALLOW this if written in (b)(i) ALLOW '1 molar' / 1M / equal concentrations of V^{2+} **and** V^{3+} / vanadium(II) **and** vanadium(III) ions All **3** correct **(2)** Any **2** correct **(1)**	298°K / 273 K / 0°C / room temperature wrong pressure units eg 100 Pa wrong concentration units eg 1 mol	**(2)**

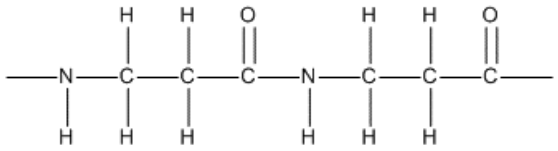
Question Number	Acceptable Answers	Reject	Mark
20(c)	**First mark – stand alone** vanadium(IV) / V(IV) / (+)4 (oxidation state) ALLOW V^{4+} **(1)** IGNORE VO^{2+} **Second mark** $E^{\ominus}_{cell}$ (= 1.00 – 0.54) = (+)0.46 (V) **(1)** **Third mark** $2VO_2^{+} + 4H^{+} + 2I^{-} \rightarrow 2VO^{2+} + 2H_2O + I_2$ ALLOW multiples / ⇌ **(1)** IGNORE any working before this equation **Fourth mark** For the reduction of V (IV) to V (III) $E^{\ominus}_{cell}$ (= 0.34 – 0.54) = −0.2(0) (V) OR $E^{\ominus}_{cell}$ for the reaction between VO^{2+} and I^{-} is negative (so V(IV) is not reduced to V(III)) OR I_2/I^{-} electrode potential / SEP / $E^{\ominus}$ value is more positive than the VO^{2+}/V^{3+} value (so V(IV) is not reduced to V(III)) OR VO^{2+}/V^{3+} electrode potential / SEP / $E^{\ominus}$ value is less positive than the I_2/I^{-} value (so V(IV) is not reduced to V(III)) **(1)** IGNORE equation for VO^{2+} and I^{-} **Fifth mark – stand alone** $E^{\ominus}_{cell}$ is positive / greater than 0 so (first) reaction is feasible **and** $E^{\ominus}_{cell}$ is negative / less than 0 so (second) reaction is not feasible ALLOW spontaneous for feasible **(1)** IGNORE incorrect values provided the signs are correct	Mention of iodide ions reduced Incorrect value	**(5)**

Total for Question 20 = 11 marks

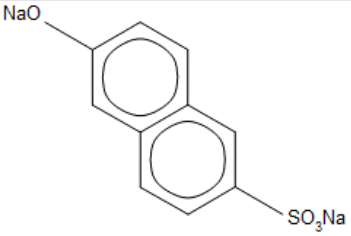
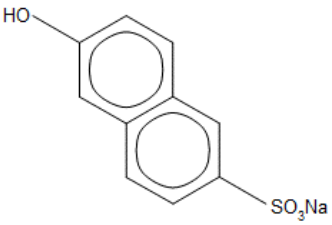
Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	2-aminopropanoic acid has peak ratio 3:2:1:1 (in any order) **(1)** 3-aminopropanoic acid has peak ratio 2:2:2:1 (in any order) **(1)** If no other mark is awarded, allow for 1 mark: 1 stated difference between the peak ratios e.g. only 2-aminopropanoic acid has a peak with area / height 3 IGNORE splitting patterns / chemical shift values even if incorrect	They have different numbers of peaks negates 1 mark only	**(2)**

Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	Not chiral, as there is no carbon atom with 4 different atoms or groups attached ALLOW Not chiral, as there is no asymmetric carbon atom / there is a plane of symmetry in the molecule / there are two hydrogens attached to (both) carbons IGNORE there is no chiral carbon atom / does not have any enantiomers IGNORE Not chiral, as mirror image is superimposable / it does not have a non-superimposable mirror image	Species /molecules	**(1)**

Question Number	Acceptable Answers	Reject	Mark
21(a)(iii)	ALLOW skeletal / displayed / structural formulae or any combination of these ALLOW CO_2H for COOH / C_2H_4 or $(CH_2)_2$ for CH_2CH_2 $^+H_3NCH_2CH_2COO^- + H^+ \rightarrow {}^+H_3NCH_2CH_2COOH$ ALLOW $H_2NCH_2CH_2COOH + H^+ \rightarrow {}^+H_3NCH_2CH_2COOH$ **(1)** $^+H_3NCH_2CH_2COO^- + OH^- \rightarrow H_2NCH_2CH_2COO^- + H_2O$ ALLOW $H_2NCH_2CH_2COOH + OH^- \rightarrow H_2NCH_2CH_2COO^- + H_2O$ **(1)** ALLOW (1) for just 2 correct organic products ALLOW (1) for 2 correct equations using 2-aminopropanoic acid		**(2)**

Question Number	Acceptable Answers	Reject	Mark
21(a)(iv)	 Extension bonds must be present and can be solid or dotted ALLOW $(CH_2)_2$ / C_2H_4 ALLOW structural / skeletal / displayed formulae or any combination of these e.g. $-NH(CH_2)_2CONH(CH_2)_2CO-$ IGNORE brackets / n	Use of 2-aminopropanoic acid 1 repeat unit /more than 2 repeat units	**(1)**

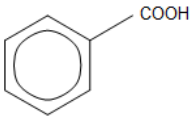
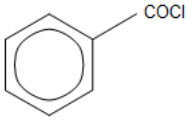
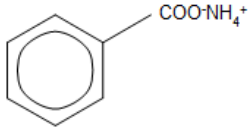
Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	sodium nitrite / sodium nitrate(III) / $NaNO_2$ **and** hydrochloric acid / HCl / sulfuric acid / H_2SO_4 ALLOW nitrous acid / HNO_2 (and hydrochloric acid / HCl) **(1)** IGNORE concentration of hydrochloric acid at 5 °C/ between 0 and 10 °C. Conditional on correct or 'near miss' reagents ALLOW any temperature or range of temperatures within range /ice bath / less than 5/10°C **(1)**	Just sodium nitrate Incorrect formula with correct name or vice versa Conc H_2SO_4	**(2)**

Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	 ALLOW $-O^-$ (Na^+) / $-SO_3^-$ Na^+ 	Covalent bond between Na and O O–H– / OH– attached to benzene ring	**(1)**

Question Number	Acceptable Answers	Reject	Mark
21(b)(iii)	Restricted rotation around N=N ALLOW no rotation ALLOW restricted / no rotation around the nitrogen / azo bridge ALLOW restricted / no rotation around the double bond	the molecule does not rotate limited rotation restricted / no rotation around C=C	**(1)**

Question Number	Acceptable Answers	Reject	Mark
21(b)(iv)	Dissolve it in the minimum amount of hot ethanol /solvent **(1)** Filter whilst still hot (to remove the insoluble impurities) ALLOW this mark if hot is omitted and it follows M1 and is followed by cool **(1)** Cool / use an ice bath (and allow crystals to form) **(1)** Filter **and** dry the crystals ALLOW any method of filtration / any suitable method of drying e.g. on filter paper / leave to dry / in a (warm) oven / put in a desiccator **(1)** IGNORE wash with ethanol /water	Add ethanol /solvent then heat To remove soluble impurities To remove insoluble impurities Use of an anhydrous salt for drying unless in a desiccator	**(4)**

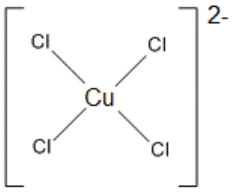
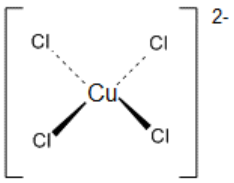
Question Number	Acceptable Answers	Reject	Mark
21(b)(v)	Compare the melting temperature with Data Book / known / literature value OR It has a sharp melting temperature OR Melting temperature is ± 2°C of the Data Book / known / literature value OR (Thin layer) chromatography has a single (yellow) spot IGNORE references to spectroscopy / HPLC / GC	boiling temperature	**(1)**

Question Number	Acceptable Answers	Reject	Mark
21(c)	IGNORE conditions unless in Reject column / mechanisms / equations ALLOW names or formulae for reagents but both must be correct if given **First step** Potassium / sodium dichromate((VI)) /$K_2Cr_2O_7$ / $Na_2Cr_2O_7$ / $Cr_2O_7^{2-}$ **and** (dilute) sulfuric acid / H^+/ acidified **(1)** ALLOW MnO_4^- / H^+ **First intermediate - stand alone**  ALLOW $–CO_2H$ / displayed formula **(1)** IGNORE formation of an aldehyde **Second step – from benzoic acid** phosphorus(V) chloride / PCl_5 / phosphorus(III) chloride / PCl_3 / thionyl chloride /$SOCl_2$ **(1)** **Second intermediate – stand alone**  ALLOW COCl displayed **(1)** **Third step – from benzoyl chloride** (concentrated) ammonia **(1)** **Alternative route for last 3 marks** **Second step – from benzoic acid** ammonium carbonate /ammonia **(1)** **Second intermediate**  ALLOW COO^- displayed / $COONH_4$ with no charges **(1)** **Third step – from ammonium benzoate** Heat OR phosphorus(V) oxide /P_2O_5/P_4O_{10} **(1)**	hydrochloric acid / HCl / concentrated H_2SO_4 just ‘benzoic acid’ hydrochloric acid/HCl Just ‘benzoyl chloride’ Ethanol Additional reagents	**(5)**

Total for Question 21 = 20 marks

Question Number	Acceptable Answers	Reject	Mark
22(a)	**First mark** Electronic configurations: Cu^{2+} is [Ar] $3d^9$ **and** Zn^{2+} is [Ar] $3d^{10}$ IGNORE $4s^0$ / full electronic configuration of Ar **(1)** **Second mark** If both EC are correct: EITHER Copper (is a transition element because it) forms a (stable) **ion** with an incompletely / partially filled **d**-subshell / orbital(s) ALLOW forms an **ion** with unpaired **d** electron(s) OR Zinc only forms an **ion** with a full **d**-subshell / all **d** orbital**s** full **(1)** If one or both EC are incorrect: Copper (is a transition element because it) forms a (stable) **ion** with an incompletely filled **d**-subshell / orbital(s) **and** zinc only forms an **ion** with a full **d**-subshell / all **d** orbital**s** full **(1)**	d shell sub-shell / orbital other than 3d	**(2)**

Question Number	Acceptable Answers	Reject	Mark
22(b)	$CuCl + AgCl \rightleftharpoons CuCl_2 + Ag$ OR $Cu^+ + Ag^+ \rightleftharpoons Cu^{2+} + Ag$ OR $CuCl + Ag^+ \rightleftharpoons Cu^{2+} + Ag + Cl^-$ ALLOW $\rightarrow$ **(1)** IGNORE state symbols / half-equations **Stand alone mark** (Equilibrium moves to the right in sunlight) producing silver **(1)** IGNORE copper(II) compounds	Copper (metal)/ copper(I) compounds	**(2)**

Question Number	Acceptable Answers	Reject	Mark
22(c)	Shape – square planar  or  ALLOW bonds with or without arrows ALLOW Cls joined by lines in a square ALLOW tetrahedral shape **(1)** IGNORE brackets and/or charges Bonding - dative (covalent) /co-ordinate ALLOW shown on diagram as arrows from Cl to Cu **(1)**		**(2)**

Question Number	Acceptable Answers	Reject	Mark
22(d)(i)	$Cu + CuCl_2 + 2HCl \rightarrow 2[CuCl_2]^- + 2H^+$ OR $Cu + Cu^{2+} + 4Cl^- \rightarrow 2[CuCl_2]^-$ OR $Cu + [Cu(H_2O)_6]^{2+} + 4Cl^- \rightarrow 2[CuCl_2]^- + 6H_2O$ OR $Cu + [Cu(H_2O)_6]^{2+} + 4HCl \rightarrow 2[CuCl_2]^- + 6H_2O + 4H^+$ OR $Cu + CuCl_2 + 2Cl^- \rightarrow 2[CuCl_2]^-$ IGNORE state symbols, even if incorrect / missing brackets		**(1)**

Question Number	Acceptable Answers	Reject	Mark
22(d)(ii)	Disproportionation is the simultaneous oxidation and reduction of a (single) species / atom / element / ion (to form 2 different oxidation states) **(1)** IGNORE reactant / substance / molecule / compound Not disproportionation because two different species (of copper) are oxidised and reduced OR Not disproportionation as (start with 2 different oxidation states of copper and) only produces 1 oxidation state ALLOW Disproportionation is the other way around / this is reverse disproportionation / comproportionation **(1)**		**(2)**

Question Number	Acceptable Answers	Reject	Mark
22(d)(iii)	The d-subshell is full / d^{10} OR **all** d orbital**s** are full ALLOW d shell is full **(1)** d-d transitions cannot take place OR Electrons cannot move between **d** orbitals OR Electrons cannot be promoted / excited to higher **d** orbital(s) **(1)** IGNORE just 'movement to different energy level'	d orbital any number other than 3(d) d-subshell / d orbitals do not split	**(2)**

Question Number	Acceptable Answers	Reject	Mark
22(e)(i)	State symbols **are** required IGNORE missing square brackets $Cu^{2+}(aq) + 2OH^{-}(aq) \rightarrow Cu(OH)_2(s)$ OR $[Cu(H_2O)_6]^{2+}(aq) + 2OH^{-}(aq) \rightarrow Cu(OH)_2(s) + 6H_2O(l)$ OR $[Cu(H_2O)_6]^{2+}(aq) + 2OH^{-}(aq) \rightarrow Cu(OH)_2(H_2O)_4(s) + 2H_2O(l)$ OR $Cu^{2+}(aq) + 2OH^{-}(aq) + 4H_2O(l) \rightarrow Cu(OH)_2(H_2O)_4(s)$ ALLOW equations with $[Cu(H_2O)_4]^{2+}(aq)$	Equations with NaOH / Na^{+}/ SO_4^{2-} ions	**(1)**

Question Number	Acceptable Answers	Reject	Mark
22(e)(ii)	Ligand exchange / ligand substitution / ligand replacement	Acid/base reaction Deprotonation	**(1)**

Question Number	Acceptable Answers	Reject	Mark
22(f)(i)	Ligand has 2 atoms that can form (co-ordinate / dative covalent) bonds (to the metal ion) ALLOW Has 2 lone pairs that form (co-ordinate / dative covalent) bonds ALLOW Has 2 lone pairs that it donates (to the metal ion) ALLOW Forms 2 (co-ordinate / dative covalent) bonds (to the metal ion)	2 ligands attached to the ion Ionic bond Just 'has 2 lone pairs'	**(1)**

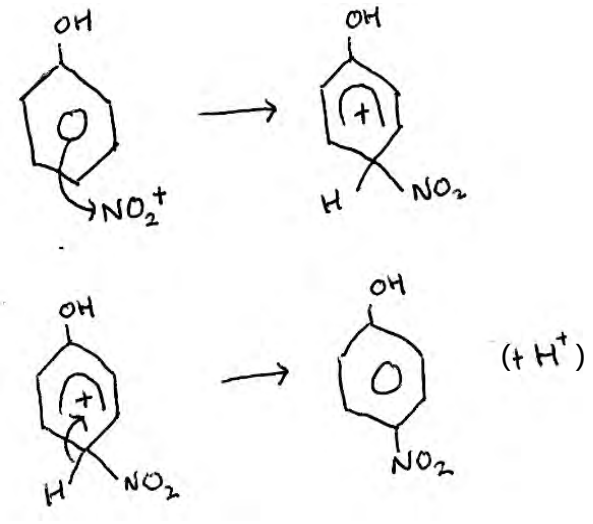
Question Number	Acceptable Answers	Reject	Mark
22(f)(ii)	**First mark** (there are) more particles / moles / species on the right (of the equation) OR (there is an increase from) 4 particles / moles / species on the left of the equation to 7 on the right **(1)** **Second mark** (so) ΔS_{system} increases / is positive (and the reaction is thermodynamically feasible) ALLOW ΔS_{total} is positive / increasing (and the reaction is thermodynamically feasible) ALLOW (there is) an increase in entropy (and the reaction is thermodynamically feasible) **(1)** IGNORE Just 'disorder increases'	Molecules / atoms Incorrect numbers of particles / moles	**(2)**

Total for Question 22 = 16 marks

Section C

Question Number	Acceptable Answers	Reject	Mark
23(a)	(acid) amide / N-substituted amide / N-substituted ethanamide / secondary (substituted) amide / substituted amide IGNORE benzene / arene / phenyl	Amine / amino acid / carboxylic acid / acid / ester	**(1)**

Question Number	Acceptable Answers	Reject	Mark
23(b)(i)	(HNO_3 + H_2SO_4 → $H_2NO_3^+$ + HSO_4^-) base/ acid/ conjugate acid/ conjugate base/ base 1 acid 2 acid 1 base 2 ALLOW any labels that connect the correct acid/base pairs, including linking lines		**(1)**

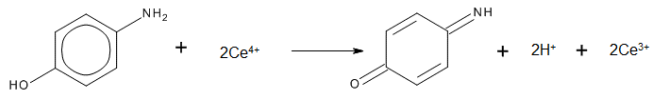
Question Number	Acceptable Answers	Reject	Mark
23(b)(ii)	If benzene used instead of phenol OR if final product is not 4-nitrophenol (max 2)  **First mark** Curly arrow from on or within the circle to the N of NO_2^+ ALLOW curly arrow from anywhere within the hexagon ALLOW curly arrow to any part of the NO_2^+ including to the + charge **(1)** **Second mark** 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 ALLOW dotted horseshoe **(1)** **Third mark** Curly arrow from C—H bond to anywhere in the hexagon, reforming the delocalised structure **(1)** IGNORE any involvement of HSO_4^- in the final step Correct Kekule structures score full marks	Lone pair on N Curly arrow on or outside the hexagon Dotted bonds to H and NO_2 unless as part of a 3-D structure Curly arrow from H	**(3)**

Question Number	Acceptable Answers	Reject	Mark
23(b)(iii)	**Lone pair of electrons on oxygen** (may be shown on a diagram) **and** EITHER overlaps with pi cloud /delocalised electrons / delocalised system OR Feeds into / donates into / interacts with (benzene) ring /delocalised electrons / delocalised system ALLOW Increases the electron density of the (benzene) ring **(1)** (Increased electron density) makes the ring more susceptible to electrophilic attack ALLOW phenol is a better nucleophile **(1)**	Ring is more electro-negative	**(2)**

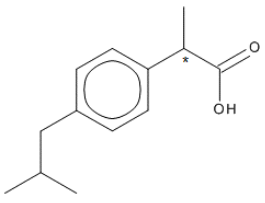
Question Number	Acceptable Answers	Reject	Mark
23(b)(iv)	Reduction ALLOW redox	Hydrogenation	**(1)**

Question Number	Acceptable Answers	Reject	Mark
23(b)(v)	ethanoyl chloride / CH_3COCl / ethanoic anhydride / $(CH_3CO)_2O$ If name and formula are given, both must be correct ALLOW displayed / skeletal formulae IGNORE acid chloride / acid anhydride	ethanoic acid / CH_3COOH	**(1)**

Question Number	Acceptable Answers	Reject	Mark
23(b)(vi)	Hydrogen bonds present in both compounds ALLOW if this is clearly implied e.g. 4-nitrophenol forms more hydrogen bonds than 2-nitrophenol **(1)** 4-nitrophenol forms intermolecular hydrogen bonds **and** 2-nitrophenol forms intramolecular hydrogen bonds (so less intermolecular hydrogen bonds) ALLOW this shown in diagrams / a clear description **(1)** IGNORE references to other intermolecular forces		**(2)**

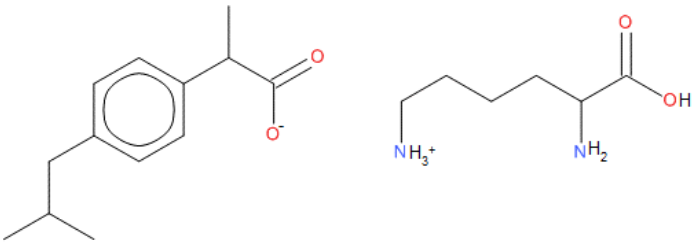
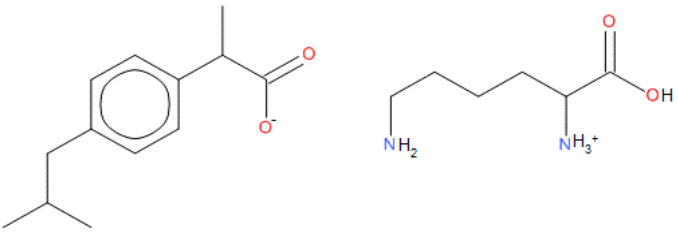
Question Number	Acceptable Answers	Reject	Mark
23(c)(i)	 OR $HOC_6H_4NH_2 + 2Ce^{4+} \rightarrow OC_6H_4NH + 2H^+ + 2Ce^{3+}$	electrons left in equation	**(1)**

Question Number	Acceptable Answers	Reject	Mark
23(c)(ii)	95.1(3)% with or without working scores **(5)** mol Ce^{4+} used = 12.60x0.100/1000 = $1.260x10^{-3}$ **(1)** mol 4-aminophenol in 20.0 cm^3 = $1.260x10^{-3}/2$ = $6.30x10^{-4}$ TE on mole ratio in (c)(i) **(1)** mol 4-aminophenol/paracetamol in 100 cm^3 = $6.30x10^{-4}$ x 5 = $3.15x10^{-3}$ TE on mol in 20.0 cm^3 **(1)** mass paracetamol in 100 cm^3 = $3.15x10^{-3}$ x 151 = 0.47565 (g) TE from mol in 100 cm^3 **(1)** % paracetamol **=** $\frac{0.47565}{0.500}$ x 100 = 95.1(3)(%) TE from mass paracetamol in 100cm^3 as long as answer is less than 100% **(1)** IGNORE SF except 1SF ALLOW alternative methods	Incorrect units once only	**(5)**

Question Number	Acceptable Answers	Reject	Mark
23(d)(i)	 ALLOW other ways of indicating the correct carbon atom eg with a circle	Circle covering additional carbon atoms More than one carbon atom indicated	**(1)**

Question Number	Acceptable Answers	Reject	Mark
23(d)(ii)	Mark independently **First mark** Any one problem from: Producing a single enantiomer / isomer gives low atom economy / gives (a lot of / 50%) waste / low yield (of required isomer) OR Separating the two enantiomers / isomers is difficult / expensive / uses (a lot of) energy **(1)** IGNORE just 'a racemic mixture is formed' / unwanted isomer may be harmful / toxic / have side effects **Second mark** Any one solution from: Produce a single isomer by using enzymes / bacteria / a biological catalyst / a chiral catalyst / chiral synthesis / asymmetric synthesis / stereospecific synthesis OR Use a (natural) chiral molecule as a starting material ALLOW Use of S_N2 instead of S_N1 **(1)** IGNORE remove harmful /unwanted products	Combinatorial chemistry Passing reactants over reagents on polymer supports	**(2)**

Question Number	Acceptable Answers	Reject	Mark
23(e)	Any **one** reason from: (The three step synthesis will) Increase atom economy / reduce waste OR Increase / give a higher (percentage) yield OR Use less energy / fuel ALLOW reverse argument for the six step synthesis IGNORE references to costs / raw materials / efficiency / pollution		**(1)**

Question Number	Acceptable Answers	Reject	Mark
23(f)	 OR  ALLOW carboxylate ion shown as  ALLOW Anion as shown and the cation with two NH_3^+ groups / cation shown as a protonated zwitterion Anion **(1)** Cation **(1)**	Charges outside brackets, once only, if both ions are correct and there are no charges inside the bracket	**(2)**

Total for Section C = 23 marks

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