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Mark Scheme (Results)

June 2014

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

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	D		**1**

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

Question Number	Correct Answer	Reject	Mark
3	C		**1**

Question Number	Correct Answer	Reject	Mark
4	C		**1**

Question Number	Correct Answer	Reject	Mark
5	D		**1**

Question Number	Correct Answer	Reject	Mark
6 (a)	B		**1**
6 (b)	C		**1**

Question Number	Correct Answer	Reject	Mark
7	D		**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	A		**1**

Question Number	Correct Answer	Reject	Mark
11	A		**1**

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

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

Question Number	Correct Answer	Reject	Mark
14 (a)	A		**1**
14 (b)	D		**1**

Question Number	Correct Answer	Reject	Mark
15	A		**1**

Question Number	Correct Answer	Reject	Mark
16	C		**1**

Question Number	Correct Answer	Reject	Mark
17	D		**1**

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

Section B

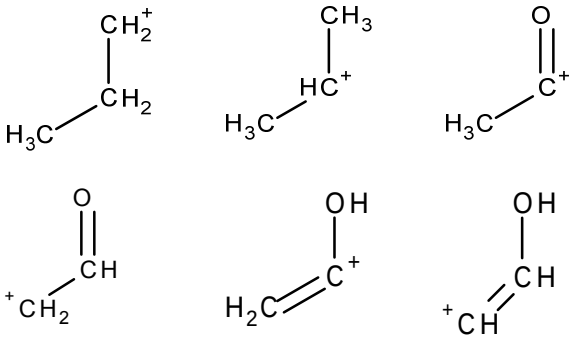
Question Number	Acceptable Answers	Reject	Mark
19 (a)(i)	So that only the water formed in the combustion is absorbed by X / measured. ALLOW 'reacts with X' for 'absorbed by X' OR Otherwise the mass / amount of the water measured will be too high	Reacts with A References to Y	**1**

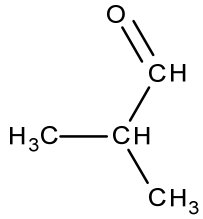
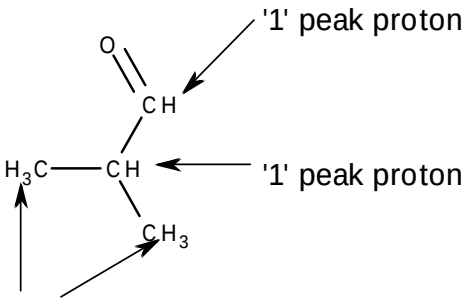
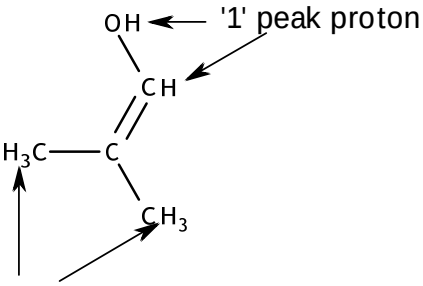
Question Number	Acceptable Answers	Reject	Mark
19 (a)(ii)	(Anhydrous) Calcium chloride / $CaCl_2$ / Magnesium sulphate / $MgSO_4$ / silica gel / sodium sulphate / Na_2SO_4 ALLOW Phosphorus(V) oxide / phosphorus pentoxide / P_4O_{10} / P_2O_5 / Silica beads	Sulfuric acid Calcium oxide Silica / SiO_2 anhydrous copper(II) sulfate	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (a)(iii)	Soda lime OR calcium hydroxide / $Ca(OH)_2$ **and** sodium hydroxide / NaOH ALLOW sodium hydroxide / NaOH / potassium hydroxide / KOH / Calcium oxide / CaO	Limewater	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (a)(iv)	The methods below illustrate the allocation of marks. But the first four marks may be scored by any correct method. **Method 1** mol CO_2 = 8.8/44 = 0.2 (= mol C) **(1)** mol H_2O = 3.6/18 = 0.2 mol H = 2 x mol H_2O = 0.4 **(1)** mass O = 3.6 – (12 x 0.2 + 1 x 0.4) = 0.8 (g) **(1)** mol O = 0.8/16 = 0.05 **(1)** **Method 2** Mass H = 3.60 x 2/18 = 0.40 (g) = 0.40 / 1 = 0.40 (mol) **(1)** Mass C = 8.80 x 12/44 = 2.4 (g) = 2.4 / 12 = 0.20 (mol) **(1)** Mass O = 3.60 – (0.40 + 2.4) = 0.80(g) **(1)** = 0.80 / 16 = 0.05 (mol) **(1)** Empirical formula = C_4H_8O **(1)** TE on incorrect moles but the ratio **must** be whole number IGNORE use of O_2 for O in the 'words' Correct empirical formula with some working at each stage scores full marks **but** Correct empirical formula with **no** working or **unclear and non-scoring** working scores final mark only		**5**

Question Number	Acceptable Answers	Reject	Mark
19 (b)(i)	(Molecular ion is m/e =) 72 (= M_r of **A**) **(1)** Molecular formula = C_4H_8O **(1)** No TE on incorrect molecular ion	 Structural Or Displayed Or Molecular ion	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (b)(ii)	Any three of (1 mark for each structure)  ALLOW structural formulae (eg CH_3CO^+) IGNORE Position of positive charge Penalise omission of charge or negative charge once $C_3H_7^+$ and /or $C_2H_3O^+$ scores 1 if no scoring structure		**3**

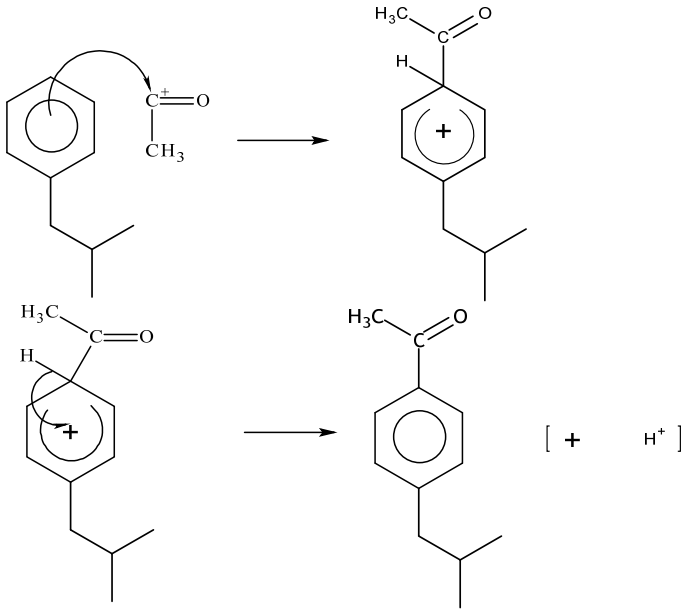
Question Number	Acceptable Answers		Reject	Mark
***19 (c)**	Structure of **A** (1)  Three (proton/H) environments (1) **Identify** the 6 protons in one environment and 1 each in the other two (1) No TE on incorrect structures except propan-2-ol : scores MP3 only	OR diagram (1)  6 proton label (1) **both** 1 proton labels (1) ALLOW enol structure  6 proton label (1) **both** 1 proton labels (1)		**3**

Total for Question 19 = 16 marks

Question Number	Acceptable Answers	Reject	Mark
20 (a)(i)	Overall **yield** higher OR Reduces use of solvents (ALLOW chemicals / reactants) OR Less loss of chemicals OR Less waste products IGNORE References to Energy / fuel / CO_2 References to atom economy More efficient conversion Fewer side products		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (a)(ii)	Lowers (operating) temperature / energy (requirements) OR Less fuel needed IGNORE References to catalyst properties such as 'lowers E_a', 'can be re-used' Atom economy		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (b)(i)	$CH_3COCl + AlCl_3 \rightarrow CH_3CO^+ + AlCl_4^-$ Structural formulae not required Positive charge may be anywhere on the electrophile. IGNORE Curly arrows even if incorrect		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (b)(ii)	 TE on incorrect electrophile in (b)(i) If benzene used instead of substituted benzene OR If final product is not 1,4 only MP 1 and 2 can be scored 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 electrophile including to the + charge (which can be anywhere on the electrophile) **(1)** Intermediate structure including charge with horseshoe covering at least 3 carbon atoms, **and** facing the tetrahedral carbon **and** with some part of the positive charge within the horseshoe ALLOW dotted horseshoe **(1)** Curly arrow from C—H bond to anywhere in the benzene ring reforming delocalized structure of a stable molecule **(1)** Correct Kekulé structures score full marks Ignore any involvement of $AlCl_4^-$ in the final step	Curly arrow on or outside the hexagon Partial bonds to H and CH_3 unless part of a 3D with a wedge bond	**3**

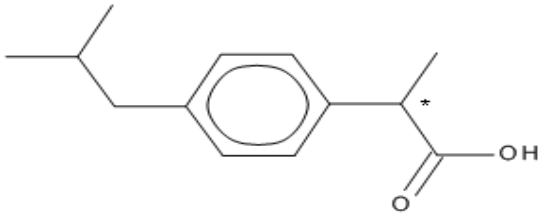
Question Number	Acceptable Answers	Reject	Mark
20 (b)(iii)	No HCl formed (as a by-product) OR Ethanoic acid easier to recover ALLOW Reverse arguments IGNORE Chlorine containing product References to ozone layer, acid rain, global warming Atom economy	Chlorine	**1**

Question Number	Acceptable Answers	Reject	Mark
20 (c)(i)	Catalyst (more) easily recovered / separated OR can be filtered OR Facilitates the use of flow (rather than batch) systems IGNORE references to properties of catalysts		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (c)(ii)	**Reaction 1** (red) phosphorus / P / P_4 and iodine / I_2 ALLOW PI_3 / HI **(1)** **Reaction 3** Hydrochloric acid / HCl(aq) or sulfuric acid / H_2SO_4 (aq) **(1)** **and** reflux / heat **(1)** Award second mark for Acid / H^+ / H_3O^+ **and** reflux OR NaOH(aq) / KOH(aq) **(1)** (reflux) **then** acidify with HCl(aq) or H_2SO_4 (aq) **(1)** IGNORE Omission of states throughout	 NaI + H_2SO_4 PI_5 Just H^+ / H_3O^+ reflux / heat without acid or with warm or <50°C	

Question Number	Acceptable Answers	Reject	Mark
20 (c)(iii)	C=O / carbonyl group (only) in carboxylic acid / ibuprofen **(1)** Absorption / peak at 1725 - 1700 (cm^{-1}) **(1)** If no other mark has been awarded, then ALLOW (for 1 mark) OH in both but in alcohol 3750 - 3200 (cm^{-1}) but in carboxylic acids 3300 to 2500 (cm^{-1})	ketone 1700 - 1680 (cm^{-1}) Single values rather than ranges	**2**

Question Number	Acceptable Answers	Reject	Mark
20 (d)(i)	(A chiral molecule is) non-superimposable on its mirror image. ALLOW Asymmetric (tetrahedral) carbon atom / has a carbon atom bonded to **four** different groups / atoms IGNORE Has two enantiomers Functional (as in functional groups) Reference to rotation of plane polarized light	molecules / species (for groups)	**1**

Question Number	Acceptable Answers	Reject	Mark
20 (d)(ii)	 ALLOW any clear indication of chiral carbon		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (d)(iii)	(A racemic mixture is) an equimolar mixture of the two enantiomers / (optical) isomers ALLOW (for equimolar mixture) equal amounts / concentrations / volumes / proportions OR 50:50 mixture	Just 'no effect on plane polarised light'	**1**

Question Number	Acceptable Answers	Reject	Mark
20 (d)(iv)	Any two of 1. All the ibuprofen is useful (rather than half) 2. No need for separation of isomers / enantiomers 3. No need for a more complex synthesis forming just one enantiomer 4. Sometimes one enantiomer has negative effects 5. Smaller dosage may be used ALLOW (For point 4 above) Dose / inactive isomer is less likely to be harmful IGNORE Reference to cost / yield / atom economy / side effects		**2**

Total for Question 20 = 18 marks

Question Number	Acceptable Answers	Reject	Mark
21 (a)(i)	$Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+} \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$ Ignore state symbols even if incorrect	Any answers with electrons even if balanced	**1**

Question Number	Acceptable Answers	Reject	Mark
21 (a)(ii)	Ignore SF except 1 SF – penalise this and/or rounding errors once only in (a)(ii) – (v) Moles of Fe^{2+} reacting in titration $= 23.85 \times 10^{-3} \times 0.255$ $= 6.08175 \times 10^{-3}$ mol * **(1)** Moles of $Cr_2O_7^{2-}$ that reacted in titration = answer * ÷ 6 $= 6.08175 \times 10^{-3} \div 6$ $= 1.013625 \times 10^{-3}$ mol **(1)** Correct answer with no working scores 2		**2**

Question Number	Acceptable Answers	Reject	Mark
21 (a)(iii)	Moles of $Cr_2O_7^{2-}$ at start $= 25 \times 10^{-3} \times 0.200$ $= 5 \times 10^{-3}$ mol** **(1)** Moles of $Cr_2O_7^{2-}$ that reacted with ethanol = answer ** – answer 21(a)(ii) $= 5 \times 10^{-3} - 1.013625 \times 10^{-3}$ $= 3.986375 \times 10^{-3}$ mol **(1)** Correct answer with no working scores 2		**2**

Question Number	Acceptable Answers	Reject	Mark
21 (a)(iv)	$CH_3CH_2OH + H_2O \rightarrow CH_3COOH + 4H^+ + 4e^-$ **(1)** 3 mol of ethanol needs 12 mol electrons supplied by 2 mol potassium dichromate(VI) ALLOW Use of oxidation numbers of C and Cr OR Use of ratio of electrons lost and gained OR Balanced equation: $3CH_3CH_2OH + 2Cr_2O_7^{2-} + 16H^+ \rightarrow 3CH_3COOH + 4Cr^{3+} + 11H_2O$ **(1)** IGNORE Uncancelled species including the 12 electrons in the last equation	Use of [O] **Just** 3 mol of ethanol reacts with 2 mol $Cr_2O_7^{2-}$	**2**

Question Number	Acceptable Answers	Reject	Mark
21 (a)(v)	Moles of ethanol that reacted with potassium dichromate(VI) = ans. 21(a)(iii) x 3 ÷ 2 = 5.9795625×10^{-3} mol **(1)** Concentration in **Q** = previous answer x 10 x 40 = 2.391825 mol dm^{-3} **(2)** (1 mark for x 10 or x 40 and 1 mark for completion of calculation Correct answer with no working scores 3		**3**

Question Number	Acceptable Answers	Reject	Mark
***21(b)**	Fe^{2+} / iron(II) **(1)** And any TWO of: Barium diphenylamine sulfonate is a **redox** indicator ALLOW reaction is **redox** **(1)** Barium diphenylamine sulfonate / indicator is reduced by iron(II) OR Iron(II) is oxidized by barium diphenylamine sulfonate / indicator OR Barium diphenylamine sulfonate / indicator oxidized by potassium dichromate(VI) OR Potassium dichromate(VI) is reduced by Barium diphenylamine sulfonate / indicator **(1)** The oxidized form / oxidation product of barium diphenylamine sulfonate is purple OR the reduced form is colourless ALLOW Oxidised and reduced form of the indicator have different colours **(1)**		**3**

Question Number	Acceptable Answers	Reject	Mark
***21(c)**	**EITHER** **MP1** Difficult to know when reaction is complete OR Difficult to know when all the ethanol has been oxidized (to ethanoic acid) OR Some ethanol only oxidized to ethanal ALLOW Some ethanol is oxidized by air **(1)** **MP2** (depends on MP1 correct or 'ethanol evaporates') So less potassium dichromate(VI) will be used up **(1)** **MP3** (depends on MP1 or MP2 or 'ethanol evaporates') Ethanol concentration will appear low **(1)** **OR** Other compounds in the fermented solution (e.g. aldehydes) are oxidized also. **(1)** So more potassium dichromate(VI) will be used up **(1)** Ethanol concentration will appear high **(1)**	Ethanol evaporates Transfer losses / spillages Not all sugar fermented	**3**

Total for Question 21 = 16 marks
Total for Section B = 50 marks

Section C

Question Number	Acceptable Answers	Reject	Mark
22 (a)	Oxygen atoms in water molecules have δ− charge. **(1)** Which form electrostatic / ion-dipole attractions with sodium (ion). **(1)** ALLOW for one mark copper(II) ions form dative covalent bonds but sodium ions do not (**both** needed)	 Ionic bonds / attractions Intermolecular forces Hydrogen bonds	**2**

Question Number	Acceptable Answers	Reject	Mark
22 (b)	Additional (dative covalent bond) lone pairs are accommodated in vacant (3)d orbitals / (3)d sub-shell ALLOW Vacant **higher** energy orbitals / sub-shells IGNORE 3s/3p	'Partially filled' for 'vacant'	**1**

Question Number	Acceptable Answers	Reject	Mark
***22 (c)(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 /electrons are excited **(1)** Absorbing energy /photons of a certain frequency (in the visible region) ALLOW Absorbing light **(1)** Reflected / transmitted / remaining light is coloured / 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 Emitted	**4**

Question Number	Acceptable Answers	Reject	Mark
22 (c)(ii)	Zn (3)d orbitals are / (3)d subshell is **full / complete** (so d−d transitions are not possible) / Zinc is $3d^{10}$	Zn does not have partially filled d subshell	**1**

Question Number	Acceptable Answers	Reject	Mark
22 (c)(iii)	(d−d) energy gap is large **(1)** the energy absorbed is outside the visible region / in the UV region **(1)** Stand alone marks		**2**

Question Number	Acceptable Answers	Reject	Mark
22 (d)	**<u>Method 1: cell emfs</u>** For the reaction $Cu(H_2O)_6^{2+}(aq) + 2S_2O_3^{2-}(aq)$ $\rightarrow Cu(s) + 6H_2O(l) + S_4O_6^{2-}(aq)$ * $E^{\ominus}_{cell} = +0.34 - 0.09 = (+)0.25$ (V) **and** (Positive so) reaction is feasible **(1)** For the reaction $Cu(H_2O)_2(NH_3)_4^{2+}(aq) + 2S_2O_3^{2-}(aq)$ $\rightarrow Cu(s) + 2H_2O(l) + 4NH_3(aq) + S_4O_6^{2-}(aq)$ ** $E^{o}_{cell} = -0.05 - 0.09 = -0.14$ (V) **and** (Negative so) reaction is not feasible **(1)** If both values correct but feasibility omitted or incorrect award 1 mark **Both** equations (* & **) correct IGNORE Omission of H_2O and states from the equations **(1)** **<u>Method 2: anticlockwise rule</u>** Place the reactions in order of increasing (more positive) $E^{\ominus}$ values and check which reaction occurs in the anticlockwise direction. **(1)** $S_4O_6^{2-}(aq) + 2e^- \rightarrow 2S_2O_3^{2-}(aq)$ $E^o = +0.09$ V $Cu(H_2O)_6^{2+}(aq) + 2e^- \rightarrow Cu(s) + 6H_2O(l)$ $E^{\ominus} = 0.34$ V Reaction is feasible (desired reaction proceeds in anticlockwise direction) **(1)** $Cu(H_2O)_2(NH_3)_4^{2+}(aq) + 2e^-$ $\rightarrow Cu(s) + 2H_2O(l) + 4NH_3(aq)$ $E^o = -0.05$ V $S_4O_6^{2-}(aq) + 2e^- \rightarrow 2S_2O_3^{2-}(aq)$ $E^o = +0.09$ V Reaction is not feasible (proceeds in the opposite direction). **(1)**	electrons in equations	**3**

Question Number	Acceptable Answers	Reject	Mark
22 (e)(i)	(coordination number =) 4 / four		**1**

Question Number	Acceptable Answers	Reject	Mark
22 (e)(ii)	Amount of complex = 4.82 / 288.7 (= 0.0166955 mol) Mass of nickel = 58.7 x 4.82 / 288.7 = 0.98003 g **(1)** % Nickel in alloy = 100 x 0.98 / 1.02 = 96.08 % **(1)** Correct answer with no working scores 2 Ignore SF except 1 ALLOW TE unless %>100 Use of A_r(Ni) = 59 (gives 96.57%)		**2**

Question Number	Acceptable Answers	Reject	Mark
22 (f)	Nickel carbonyl is a gas (so can be easily separated from impurities).		**1**

Question Number	Acceptable Answers	Reject	Mark
22 (g)	Silver(I) oxide is precipitated in alkaline solution OR Silver(I) ions need to be in solution OR (Ammonia) prevents precipitation of silver(I) oxide **(1)** Formation of diamminesilver(I) lowers concentration of $Ag^+(aq)$ OR Equilibrium 2 shifts to the right by addition of ammonia **(1)** (lower $[Ag^+]$) causes equilibrium 1 to shift to the left **(1)** IGNORE Omission of oxidation state of silver		**3**

Total for Question 22 = 20 marks

Total for Section C = 20 marks

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