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Mark Scheme (Results)

Summer 2013

GCE Chemistry 6CH05/01R
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	C		**1**

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

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

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

Question Number	Correct Answer	Reject	Mark
5(a)	C		**1**
(b)	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	D		**1**

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

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

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

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

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

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

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

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

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

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

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

Total for Section A = 20 Marks

Section B

Question Number	Acceptable Answers	Reject	Mark
20(a)(i)	$Cr_2(SO_4)_3(aq) = Cr(H_2O)_6^{3+}$ ALLOW $Cr^{3+}(aq)$ / Cr^{3+} **(1)** A = $Cr(H_2O)_3(OH)_3$ / $Cr(OH)_3$ **(1)** B = $Cr(H_2O)_2(OH)_4^-$ / $Cr(OH)_4^-$ / $Cr(OH)_6^{3-}$ **(1)** C = CrO_4^{2-} **(1)** IGNORE SO_4^{2-} and/or Na+		**4**

Question Number	Acceptable Answers	Reject	Mark
20(a)(ii)	$H_2O_2 + 2e^{(-)} \rightarrow 2OH^-$		**1**

Question Number	Acceptable Answers	Reject	Mark
20(a)(iii)	Sulfuric acid / H_2SO_4 ALLOW Name or formula of any strong acid (e.g. HCl) IGNORE H^+ and 'an acid' Dilute or concentrated		**1**

Question Number	Acceptable Answers	Reject	Mark
20(a)(iv)	$2CrO_4^{2-} + 2H^+ \rightarrow Cr_2O_7^{2-} + H_2O$ ALLOW Equation showing Na^+ and anion on both sides IGNORE State symbols even if incorrect	Non-ionic equations	**1**

Question Number	Acceptable Answers	Reject	Mark
20(b)	**First mark for both half equations** Mentions / some evidence for the use of BOTH half equations in any way even if reversed or left unbalanced $Cr^{3+}(aq) + e^- \rightarrow Cr^{2+}(aq)$ ($E^\ominus = -0.41$ V) $Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^-$ $\rightarrow 2Cr^{3+}(aq) + 7H_2O(l)$ ($E^\ominus = +1.33$ V) **(1)** **Second mark for** $8Cr^{3+}(aq) + 7H_2O(l) \rightarrow 6Cr^{2+}(aq) + Cr_2O_7^{2-}(aq) + 14H^+(aq)$ **(1)** **Third mark for** $E^\ominus_{cell} = -0.41 - 1.33 = -1.74$ (V) For **second** and **third marks,** ALLOW reverse equation and $E^\ominus_{cell} = +1.74$ (V) (for **reverse** reaction) **(1)** ALLOW 1.74 (V) only if 'positive' stated in words elsewhere **Fourth mark for** EITHER Disproportionation / (proposed) reaction / "it is" **not feasible** (because its $E^\ominus_{cell}$ is negative) OR Reverse of disproportionation **is feasible** (because its $E^\ominus_{cell}$ is positive) **(1)** IGNORE state symbols even if incorrect ALLOW $\rightleftharpoons$ instead of $\rightarrow$ Third and fourth marks can be awarded CQ on incorrect half equation(s) and stated $E^\ominus$ values		**4**

Total for Question 20 = 11 Marks

Question Number	Acceptable Answers	Reject	Mark
21(a)	−285.8 / −286 (kJ mol^{-1})		**1**

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	$H_2(g) + 2OH^-(aq) \rightarrow 2H_2O(l) + 2e^{(-)}$ **(1)** $O_2(g) + 2H_2O(l) + 4e^{(-)} \rightarrow 4OH^-(aq)$ **(1)** **For state symbols mark:** Two of the four stated equations (see the two equations above and the two equations below) must be quoted even if reversed or unbalanced. All state symbols must be correct in **both** equations for correct species for the state symbol mark (penalise once only) **(1)** Both equations for an **acid** fuel cell score max 2 (1 for correct equations and 1 for states) e.g. $H_2(g) \rightarrow 2H^+(aq) + 2e^{(-)}$ OR $H_2(g) - 2e^{(-)} \rightarrow 2H^+(aq)$ $O_2(g) + 4H^+(aq) + 4e^{(-)} \rightarrow 2H_2O(l)$ ALLOW Equation multiples Equations in reverse direction Any order of equations Reversible arrows		**3**

Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	Electrolyte / to allow the movement of ions (between electrodes) ALLOW Movement of hydrogen ions/ oxonium ions / hydroxonium ions / hydronium ions / H^+ / H_3O^+ / hydroxide ions / OH^- (between electrodes) IGNORE References to electron transfer	Catalyst Just 'conducts electricity' Movement of other ions / charged species	**1**

Question Number	Acceptable Answers	Reject	Mark
21(b)(iii)	Any two of Both involve breaking / weakening bonds OR Both involve active site(s) (on the catalyst surface) OR **Ad**sorption **(2)** IGNORE Lowers the activation energy Both heterogeneous References to surface area or "surface for the reaction" References to orientation of reactant molecules "Reaction pathway is similar"	**Ab**sorption	**2**

Question Number	Acceptable Answers	Reject	Mark
21(c)(i)	Water is the **only** product (at the point of use) / **no** oxide(s) of carbon IGNORE Reference to efficiency and/or high energy density Greener	**Less** oxide(s) of carbon	**1**

Question Number	Acceptable Answers	Reject	Mark
21(c)(ii)	**Any two from:** Fuel cell is more efficient / 70% efficient ALLOW Any % between 70% and 100% It produces electricity directly OR **Less** heat loss Releasing energy in a more controlled manner **(2)** IGNORE References to safety	Any mention of carbon emissions	**2**

Question Number	Acceptable Answers	Reject	Mark
21(c)(iii)	**Either** High cost / expensive OR Cost of catalyst OR Short life-span IGNORE References to liquefaction and / or storage of hydrogen / size / weight		**1**

Question Number	Acceptable Answers	Reject	Mark
21(c)(iv)	**Any two from** Ethanol renewable / sustainable / carbon neutral / availability of raw materials / low(er) carbon footprint / made from natural processes e.g. fermentation or biomass Less explosive / less flammable / safe(r) Easier to store / pressure not needed for storage / easier to transfer Fuel tank light(er) / small(er) New petrol stations not required ALLOW Reverse arguments for hydrogen IGNORE Reference to cost References to energy density		**2**

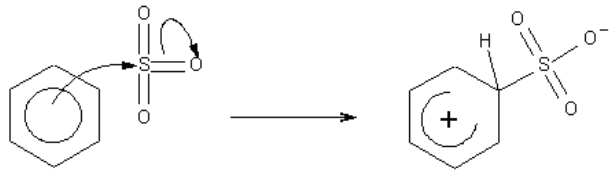
Total for Question 21 = 13 Marks

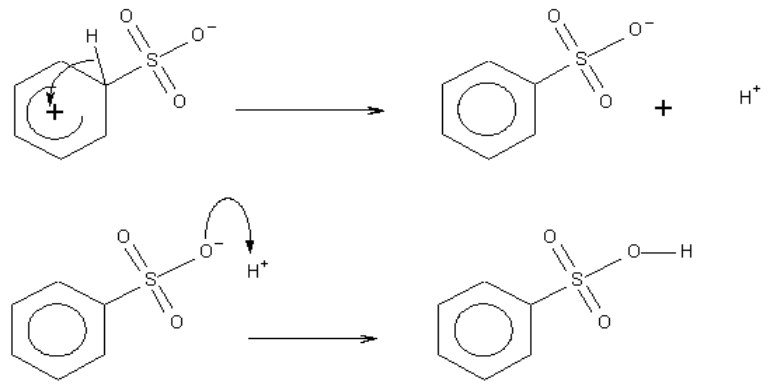
Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	**Fuming** sulfuric acid / **fuming** H_2SO_4 / oleum / $H_2S_2O_7$	Conc. (for fuming) Fuming dilute sulfuric acid **Just** sulfuric acid **Just** H_2SO_4	**1**

Question Number	Acceptable Answers	Reject	Mark
22(a)(ii)	Sulfur is δ+ and on at least one oxygen δ- **(1)** Oxygen is (much) more electronegative than sulfur ALLOW Oxygen is very electronegative **(1)**	Full + or – charge(s) 1/3 – on each oxygen	**2**

Question Number	Acceptable Answers	Reject	Mark
22 (a)(iii)	The sulfur trioxide can accept a pair of electrons OR (Three oxygen atoms so) sulfur has a large δ or partial / slight positive charge OR π bonds allow S—O bonds to be polarized more easily ALLOW Electron-deficient sulfur	An electron	**1**

Marks for (b)(i) and (b)(ii) can be awarded from either of the two annotated diagrams on item

Question Number	Acceptable Answers	Reject	Mark
22(b)(i)	 First curly arrow as shown to start inside the hexagon to the S atom **(1)** Second curly arrow from bond to O (i.e. not from the S atom itself) **(1)** ALLOW Second curly arrow to any of the three O atoms in SO_3 IGNORE A full + charge on S		**2**

Question Number	Acceptable Answers	Reject	Mark
22 (b)(ii)	 Curly arrow as shown from the C-H bond to reform the ring in first line, not from the H atom in this bond **(1)** Intermediate anion formed in first line (H^+ does not have to be shown) **(1)** Last line with curly arrow and correct structure of benzenesulfonic acid **(1)** ALLOW Use of H_2SO_4 for H^+ with HSO_4^- as other product in final step The marks for (b)(ii) may be awarded from annotations on the right hand structure given in question in (b)(i) If contradictory arrows drawn on structure in question (b)(ii), then penalise any such inconsistency The three marks for the two steps in (b)(ii) can be shown in one step / diagram / structure ALLOW $-SO_3H$ undisplayed	Use of H_2O for H^+ $-HSO_3$	**3**

Question Number	Acceptable Answers	Reject	Mark
22(c)(i)	$C_6H_5SO_3H + 3NaOH \rightarrow C_6H_5ONa + Na_2SO_3 + 2H_2O$ **(1)** ALLOW Charges on $C_6H_5O^-Na^+$ $C_6H_5ONa + HCl \rightarrow C_6H_5OH + NaCl$ **(1)** ALLOW $C_6H_5O^- + HCl \rightarrow C_6H_5OH + Cl^-$ OR $C_6H_5O^- + H^+ \rightarrow C_6H_5OH$	Charges on $C_6H_5SO_3H$	**2**

Question Number	Acceptable Answers	Reject	Mark
22(c)(ii)	**Any two from:** (Both) products useful / both are useful / propanone is useful So less waste / high(er) atom economy Fewer steps / one step / does not require many steps (in Hock synthesis) Continuous rather than a batch process **(2)** IGNORE "Only one waste product in Hock" Comments relating to hazardousness of reactants / safety / energy requirements References to yield References to efficiency References to rate	Cheaper	**2**

Total for Question 22 = 13 Marks

Question Number	Acceptable Answers	Reject	Mark
23(a)(i)	Lone pair(s) (of electrons on the nitrogen) ALLOW Non-bonded pair(s)	Spare pair	**1**

Question Number	Acceptable Answers	Reject	Mark
23(a)(ii)	$CH_3CH_2CH_2CH_2NH_2 + H_2O \rightleftharpoons CH_3CH_2CH_2CH_2NH_3^+ + OH^-$ ALLOW $\rightarrow$ for $\rightleftharpoons$ IGNORE state symbols even if incorrect Right hand ions must be shown separately ALLOW $C_4H_9NH_2$	Reject near misses	**1**

Question Number	Acceptable Answers	Reject	Mark
23(a)(iii)	**Any two of:** Butyl / alkyl groups are electron donating / are electron pushing / are electron releasing Two (alkyl) groups in dibutylamine (but only one in butylamine) **Lone pair** (of electrons) on the nitrogen more readily available / higher electron density on the nitrogen or NH_2 or amine group / N more delta negative / N or NH_2 accepts a proton more readily **(2)** Stand alone marks Accept reverse argument for butylamine IGNORE 'electronegativity of nitrogen increasing'		**2**

Question Number	Acceptable Answers	Reject	Mark
23(a)(iv)	**First mark** For the idea of the **lone pair** being withdrawn towards the ring e.g. Lone pair pulled into the ring Lone pair (of electrons) on the nitrogen overlap Lone pair interacts with π electrons / lone pair interacts with delocalized electrons of the (benzene) ring Lone pair (of electrons) on the nitrogen donated to the (benzene) ring **(1)** NOTE The reference to the lone pair may be found in a later part of the answer and credited **Second mark** EITHER For the idea of the **lone pair** being less available OR The **nitrogen** (atom) must be specified as below e.g. Lone pair is less readily available Nitrogen (atom) has lower electron density N (atom) or lone pair is less able to accept protons / H^+ **(1)** ALLOW N is less δ^- for second mark		**2**

Question Number	Acceptable Answers		Mark
23(b)	I $(Cu(H_2O)_6^{2+} + 2C_4H_9NH_2) \rightarrow Cu(H_2O)_4(OH)_2 + 2C_4H_9NH_3^+$ ALLOW I $(Cu(H_2O)_6^{2+} + 2C_4H_9NH_2) \rightarrow Cu(OH)_2 + 2C_4H_9NH_3^+ + 4H_2O$ **(2)** II $(Cu(H_2O)_6^{2+} + 4C_4H_9NH_2) \rightarrow Cu(H_2O)_2(C_4H_9NH_2)_4^{2+} + 4H_2O$ ALLOW II $(Cu(H_2O)_6^{2+} + 4C_4H_9NH_2) \rightarrow Cu(C_4H_9NH_2)_4^{2+} + 6H_2O$ **(2)** Each correct equation scores 2 marks: 1 mark for the formula of the copper complex ion and 1 mark for the rest of the equation being correct Ligands can be in either order IGNORE state symbols even if incorrect IGNORE (lack of) square brackets around complex ions		**4**

Question Number	Acceptable Answers	Reject	Mark
23(c)	Reaction is a nucleophilic substitution **(1)** It is unusual because benzene normally reacts with electrophiles / by electrophilic substitution OR Positive charge withdraws electrons from the ring (making it susceptible to nucleophilic attack) OR Expect nucleophiles to be repelled by the electron density of the ring **(1)**		**2**

Total for Question 23 = 12 Marks

Total for Section B = 49 Marks

Section C

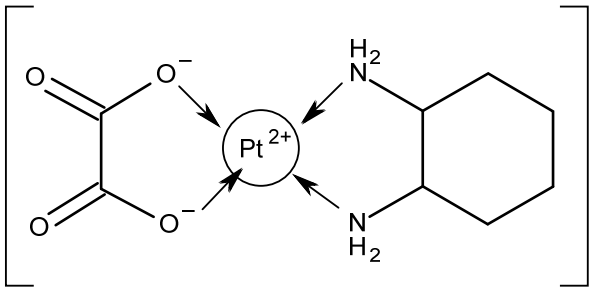
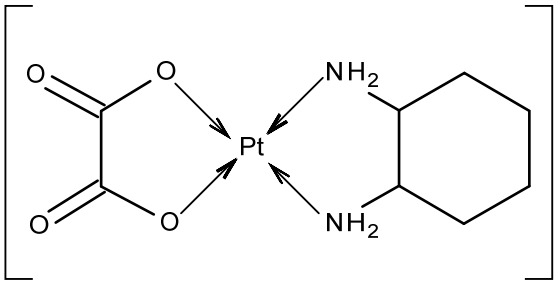
Question Number	Acceptable Answers	Reject	Mark
24(a)(i)	The electron withdrawing effect of the (extra) COOH group / oxygen atoms **(1)** Increases the stability of the (hydrogenethanedioate) ion ALLOW Weakens the OH bond **(1)** IGNORE Reference to OH bond becoming more polar		**2**

Question Number	Acceptable Answers	Reject	Mark
24(a)(ii)	H^+ ions formed (in first dissociation) shifts (second equilibrium) to the left ALLOW H^+ formed suppresses (second) ionization		**1**

Question Number	Acceptable Answers	Reject	Mark
24(b)(i)	Colourless to (pale) pink ALLOW purple for pink	Clear for colourless	**1**

Question Number	Acceptable Answers	Reject	Mark
24(b)(ii)	Amount of MnO_4^- = 28.55 x 10^{-3} x 0.0200 (= 5.71 x 10^{-4} mol) **(1)** Amount of $C_2O_4^{2-}$ = 5.71 x 10^{-4} x $\frac{5}{2}$ **(1)** = 1.4275 x 10^{-3} (mol) Amount of $C_2O_4^{2-}$ in 250 cm^3 / rhubarb leaves = 1.4275 x 10^{-3} x 10 = 1.4275 x 10^{-2} (mol) **(1)** Mass $H_2C_2O_4$ in 250 cm^3 = 1.4275 x 10^{-2} x 90 **(1)** = 1.28475 g % $H_2C_2O_4$ in rhubarb = $\frac{1.28475}{250}$ x 100 = 0.5139 % **(1)** IGNORE SF except 1 SF Correct answer with no working scores 5 TE on all parts of calculation If M_r = 88 used then final answer is 0.50248%		**5**

Question Number	Acceptable Answers	Reject	Mark
24(c)(i)	(Ligand that) Has two lone pairs that can bond (separately) (to the central ion / atom) OR Occupies two coordination positions (around a central ion / atom) OR Two points of attachment (to the central ion / atom) OR Forms two **dative** bonds (to the central ion / atom) OR Two atoms of the same ion / molecule that bond with central metal ion / atom	Two ligands **Just** two lone pairs	**1**

Question Number	Acceptable Answers	Reject	Mark
24(c)(ii)	 Or  Square planar shape around Pt drawn as above and zero net charge NOTE The structure of each ligand must be totally correct **(1)** Both nitrogen atoms attached **and** both C-O oxygen atoms attached from separate COO^- groups **(1)** **Dative** covalent bonds **(1)** **Mark each point separately**	Different oxygen atoms from the same carboxyl group attached to different coordination positions. If O attached from a C=O oxygen	3

Question Number	Acceptable Answers	Reject	Mark
24(d)(i)	(Alkaline or neutral or acidified) potassium manganate(VII) / $KMnO_4$ / MnO_4^- **(1)** Forms ethane-1,2-diol (name or structural / skeletal / displayed formula) **(1)** NOTE It does not matter how the ethane-1,2-diol has been formed (Oxidized by) (refluxing with) acidified potassium dichromate(VI) / $Cr_2O_7^{2-}$ and H^+ OR Acidified/alkaline potassium manganate(VII) / MnO_4^- with either H^+ or OH^- OR (Oxidized by) nitric acid (c.f. passage) **(1)** **Mark each point separately** Max 2 for a three step synthesis e.g. bromine followed by NaOH then oxidation ALLOW correct formulae instead of names	Molecular formula $C_2H_6O_2$ Air catalyzed by V_2O_5	**3**

Question Number	Acceptable Answers	Reject	Mark
24(d)(ii)	Carbohydrates and / or glucose are obtained from renewable / sustainable resources (whereas ethene is obtained from crude oil) ALLOW Reverse argument for ethene		**1**

Question Number	Acceptable Answers	Reject	Mark
24(d)(iii)	**Ethanedioic acid** Will have one (singlet) peak / hydrogen environment (due to the COOH protons) **(1)** **Propanoic acid** Will have three peaks / three hydrogen environments **(1)** Triplet, quartet / quadruplet & singlet in any order OR Split(ting) pattern 3,4,1 in any order **(1)** NOTE If first mark for **propanoic acid** hasn't been awarded "triplet, quartet / quadruplet & singlet" **scores 2** Intensity in ratio 3:2:1 in any order **(1)** ALLOW labelled and annotated diagrams Max. 3 if not clear that hydrogens/protons give rise to the peaks		**4**

Total for Section C = 21 Marks

Total for Paper = 90 Marks

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