Electrochemistry

Mark Scheme

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	Transition Metals & Organic Nitrogen Chemistry
Sub Topic	Electrochemistry
Booklet	Mark Scheme

Time Allowed: **64 minutes**

Score: **/53**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

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

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

Question Number	Correct Answer	Reject	Mark
6	C		1

Question Number	Correct Answer	Reject	Mark
7	A		1

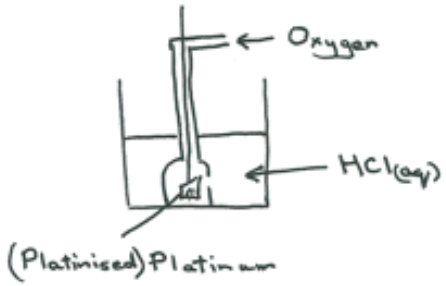
Question Number	Correct Answer	Reject	Mark
8	D		1

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	B		1

Question Number	Correct Answer	Reject	Mark
12	A		1

Question Number	Correct Answer	Reject	Mark
13(a)	Mark independently  Glassware with oxygen **and** 1 atm pressure Tube carrying oxygen must be open at the bottom **but** not after the feed at the top **(1)** (Platinised) platinum/Pt (electrode) **and** 298 K/ 25^{o}C **(1)** Hydrochloric acid/HCl(aq), **covering** some of the electrode **and** 1 mol dm^{-3} OR 1 mol dm^{-3} H^+ covering electrode **(1)** A fully correct hydrogen electrode **2max**	Sulfuric acid	3

Question Number	Correct Answer	Reject	Mark
13(b)	$CH_3OH + 1½O_2 \rightarrow CO_2 + 2H_2O$ OR multiples	Uncancelled electrons, H^+ ions and **H_2O**	1

Question Number	Correct Answer	Reject	Mark
13(c)	$E^{\ominus}_{cell}$ = +1.23 – 0.02 = (+) 1.21 (V)	- 1.21 (V)	1

Question Number	Correct Answer	Reject	Mark
13(d)	**Additional Comment** Note that the words advantage and disadvantage are not required **(Advantages)** Any one from: Easier to store/transport than hydrogen (as a liquid rather than a gas) OR Methanol can be produced from waste / methanol is renewable OR Energy per volume is greater **(1)** IGNORE Hydrogen is flammable/ explosive **(Disadvantages)** Any one from: Produces CO_2 OR Low efficiency OR Limited power/energy **(1)** OR Lower emf/E value IGNORE Land used up in producing methanol instead for crops		2

(Total for Question 13 = 7 marks)

Question Number	Acceptable Answer	Reject	Mark
14(a)(i)	$Fe(s) + H_2SO_4(aq) \rightarrow FeSO_4(aq) + H_2(g)$ OR $Fe(s) + 2H^+(aq) \rightarrow Fe^{2+}(aq) + H_2(g)$ OR ionic equations including sulfate ions OR multiples		1

Question Number	Acceptable Answer	Reject	Mark
14(a)(ii)	Otherwise the Fe^{2+} formed will oxidize ALLOW So air / oxygen cannot enter the flask To prevent reaction with air /oxygen **(1)** Hydrogen can escape through the slit OR So pressure does not build up **(1)** IGNORE Acid spray	Iron/steel oxidized	2

Question Number	Acceptable Answer	Reject	Mark
14(a)(iii)	Transfer the reaction mixture to a ($250\ cm^3$) **volumetric/graduated** flask ALLOW standard flask **(1)** (Rinse conical flask and) add washings to the volumetric flask **(1)** Make solution up to the mark (with distilled water/sulfuric acid) **and then** mix ALLOW any indication of mixing **(1)** IGNORE Filtration	Using other liquids	3

Question Number	Acceptable Answer	Reject	Mark
14(a)(iv)	$5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$ OR multiples Ignore state symbols even if incorrect		1

Question Number	Acceptable Answer	Reject	Mark
14(a)(v)	Amount MnO_4^- = 22.15 x 0.0195 /1000 **(1)** = 4.31925×10^{-4} ans* Amount Fe^{2+} = 5 x ans* **(1)** = 2.159625×10^{-3} ans** Mass of iron in wire = 10 x ** x 55.8 **(1)** = 1.20507 (g) ans*** % purity = 100 x ans*** / 1.25 = 96.40566 = 96.4 % **(1)** Ignore rounding errors until final answer Correct answer (96.4%) with or without working scores 4 ALLOW Use of Ar(Fe) = 56 when Amount MnO_4^- = 22.15 x 0.0195 /1000 **(1)** = 4.31925×10^{-4} ans* Amount Fe^{2+} = 5 x ans* **(1)** = 2.159625×10^{-3} ans** Mass of iron in wire = 10 x ** x 56 **(1)** Mass of iron in wire = 1.20939 % purity = 96.7512 = 96.8 % **(1)** Ignore intermediate rounding until final answer Correct answer (96.8%) with or without working scores 4 TE on each stage in the calculation % purity > 100 scores max 2	Answer not to 3 SF Answer not to 3 SF	4

Question Number	Acceptable Answer	Reject	Mark
14(a)(vi)	Colourless / pale yellow to (pale) pink / first permanent pink	 Purple Just '(pale) pink'	1

Question Number	Acceptable Answer	Reject	Mark
14(a)(vii)	(More manganate(VII) is needed to oxidize Fe^{2+}, so) titre will be larger **(1)** Stand alone mark Because the Mn oxidation number changes from 7 to 4 (rather than 2) OR Mn accepts fewer electrons per mole **(1)** (Brown precipitate is) manganese(IV) oxide / MnO_2 ALLOW $Mn(OH)_4$ **(1)** IGNORE References to inaccurate / inconsistent titre values	 $Mn(OH)_2$	3

Question Number	Acceptable Answer	Reject	Mark
14(b)(i)	Anodic area: $Fe^{2+} + 2e(^-) \rightleftharpoons Fe$ ($E^\ominus = -0.44$ V) OR $Fe \rightleftharpoons Fe^{2+} + 2e(^-)$ **(1)** Cathodic area: $O_2 + 2H_2O + 4e(^-) \rightleftharpoons 4OH^-$ ($E^\ominus = +0.40$ V) **(1)** ALLOW $½O_2 + 2H^+ + 2e(^-) \rightleftharpoons H_2O$ ($E^\ominus = +1.23$ V) Penalise omission of electrons or use of cell diagrams once only Anode and cathode reversed max 1. IGNORE State symbols even if incorrect Single arrow in equations		2

Question Number	Acceptable Answer	Reject	Mark
14(b)(ii)	$E^{\ominus}_{cell}$ = (+)0.40 – (−0.44) = (+)0.84 (V) ALLOW $E^{\ominus}_{cell}$ = (+)1.23 – (−0.44) = (+)1.67 (V) Correct answer with no working scores 1		1

Question Number	Acceptable Answer	Reject	Mark
14(b)(iii)	Dissolved salt makes the **water** a better conductor (of ions) OR The **solution** acts like a salt bridge OR Makes it an (effective) electrolyte OR Improves the flow of ions through the **solution** ALLOW Improves the flow of electrons through the **metal**	Improves the flow of ions through the metal Improves the flow of electrons through the solution	1

Question Number	Acceptable Answer	Reject	Mark
14(b)(iv)	Magnesium has a more negative $E^{\ominus}$ (allow more reactive) **and** so reduces the Fe^{2+} OR suppresses the oxidation of iron OR forces the iron (in the absence of oxygen) to act as the cathode ALLOW Mg corrodes / oxidizes in preference to / faster than (the Fe / steel) OR Magnesium acts as a sacrificial anode	Just 'sacrificial protection'	1

Total for Question 14 = 20 marks

Question Number	Acceptable Answers	Reject	Mark
15(a)(i)	(pale) pink OR First permanent pink Ignore 'Colourless to'	purple	

Question Number	Acceptable Answers	Reject	Mark
15(a)(ii)	$2MnO_4^- + 5C_2O_4^{2-} + \mathbf{16}H^+ \rightarrow \mathbf{2}Mn^{2+} + \mathbf{10}CO_2 + \mathbf{8}H_2O$		1

Question Number	Acceptable Answers	Reject	Mark
15(a)(iii)	Amount MnO_4^- = 24.55 x .0205 x 10^{-3} **(1)** = 5.03275 x 10^{-4} mol (ans *) Amount $C_2O_4^{2-}$ in 25 cm^3 = ans. * x 5 /2 = 5.03275 x 10^{-4} x 5/2 **(1)** = 1.2581875 x 10^{-3} mol In 250 cm^3 = 1.2581875 x 10^{-2} mol (ans **) **(1)** = amount Ca^{2+} = amount $CaCO_3$ Mass $CaCO_3$ = (ans**) x 100.1 = 1.2581875 x 10^{-2} x 100.1 **(1)** = 1.2594457 g (ans***) % $CaCO_3$ = 100 x (ans***) / 1.77 = 71.15512 = 71.2 (%) **(1)** ALLOW Final answer 71.1 / 71.2 / 71.3 scores 5 marks Final answer must be to 3 SF (max 4 if not) Until final answer ignore SF except 1 SF (penalise once) TE at each stage unless mass $CaCO_3$ > 1.77 NOTE Use of ethanedioate mass of 88 in step 4 gives final answer of 62.6% (max 4) Use of calcium ethanedioate mass of 128.1 / 128 in step 4 gives final answer of 91.0% (max 4)		5

Question Number	Acceptable Answers	Reject	Mark
15(b)(i)	Excess ethanedioate (ions in the solution) must be removed **(1)** ALLOW Remove ethanedioic acid Otherwise more $KMnO_4$ will be used (in the titration) / bigger titre **(1)** MP2 dependent on MP1	Impurities Acid	2

Question Number	Acceptable Answers	Reject	Mark
15 (b)(ii)			2

Apparatus	**Value**	**Maximum total error on the stated value**	**Percentage error on the stated value**
Balance	1.77 g	±0.01 g	0.56 (0.56497)
Volumetric flask	250 cm^3	±0.12 cm^3	0.048
Pipette	25 cm^3	±0.06 cm^3	0.24
Burette	24.55 cm^3	±0.10 cm^3	0.41 (0.40733)

All % calculations correct **(2)**
Any two or three calculations correct **(1)**

1 mark lost if 2 or more correct answers are not given to 2 SF

Question Number	Acceptable Answers	Reject	Mark
15(b)(iii)	**t mark** EITHER Max. mass of CaC_2O_4 precipitated = 0.015 x 128.1 = 1.9215 g OR 0.0067/2 = 0.00335 g remains in solution **(1)** **Second Mark** % error = 100 x 0.00335 / (1.9215 + 0.00335) = 100 x 0.00335 / 1.92485 = 0.174040 = 0.174 % ALLOW % error = 100 x 0.00335 / 1.9215 = 0.174343 = 0.174 % If M_r (CaC_2O_4) = 128 used = 0.174479 % **(1)** **Third Mark** Error comparable to / smaller than apparatus uncertainty / less than the worst / less than the balance / less than the total And so acceptable **(1)** IGNORE SF but penalise incorrect rounding once NOTE No TE for mark 2 from mark 1 BUT TE for mark 3. Accept reverse argument for large percentage.		3

Total for Question 15 = 14 marks