Electrochemistry

Mark Scheme

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	Chemistry Lab Skills 2
Sub Topic	Electrochemistry
Booklet	Mark Scheme

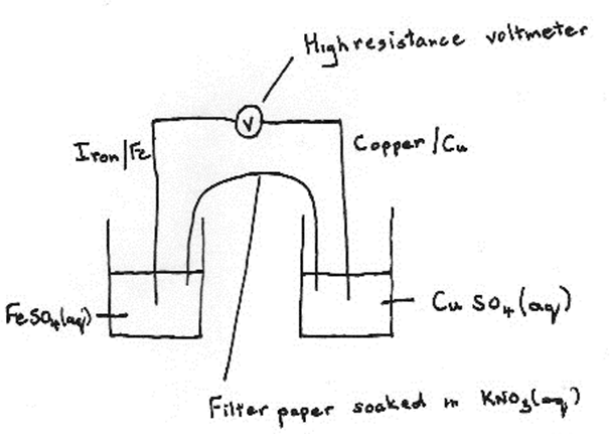
Time Allowed: **27 minutes**

Score: **/22**

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 (a)	 **First mark** Copper half cell Copper electrode dipping into copper(II) sulfate solution / solution **A** / Cu^{2+} (solution) **(1)** **Second mark** Iron half cell Iron electrode dipping into iron(II) sulfate solution/solution **B** / Fe^{2+} (solution) **(1)** Cells can be on either side Note that two platinum electrodes, or copper and iron electrodes the wrong way round loses both of the first two marks. IGNORE charges (in symbols or words) on the electrodes, even if incorrect **Third mark** Salt bridge Strip of **filter paper** with **potassium nitrate** solution / solution **C** dipping into both solutions **(1)** Only penalise electrodes / filter paper not dipping into solutions once. **Fourth mark** Circuit Voltmeter **X** / high resistance voltmeter correctly connected with or without crocodile clips **(1)**	Platinum/ Pt / iron / Fe Electrode Platinum / Pt / copper / Cu Electrode Just 'salt bridge' Any combination of meters Battery or power supply Parallel wire across voltmeter	**4**

Question Number	Correct Answer	Reject	Mark
1(b)(i)	$E_{cell} = E_{Cu} - E_{Fe}$ **(1)** $0.79 = 0.34 - E_{Fe}$ $E_{Fe} = 0.34 - 0.79 = -0.45$ (V) **(1)** Correct answer with no working **(2)** (+)0.45 (V) scores (1) only TE is allowed for wrong working with consistent answer, for example: $E_{cell} = E_{Fe} - E_{Cu}$ $0.79 = E_{Fe} - 0.34$ $E_{Fe} = 0.79 + 0.34 = (+)1.13$ (V) Award second mark only		**2**

Question Number	Acceptable Answers	Reject	Mark
1(b)(ii)	$-0.45 = -0.44 + 0.013 \ln [Fe^{2+}]$ $\ln [Fe^{2+}] = (-0.45 + 0.44)/0.013$ **(1)** $= -0.769$ $[Fe^{2+}] = \exp(-0.769) = 0.46348$ $= 0.46$ (mol dm^{-3}) **(1)** ACCEPT any answer which gives 0.46 when rounded to 2 sf Correct answer with no working **(2)** 0.76 gives 0.46761 = 0.47 worth (1) ALLOW TE from (b)(i) is allowed. Notice this may mean that the concentration is greater than 10 mol dm^{-3} which is allowed even though impossible. SOME EXAMPLES ARE: +0.45 V gives $\ln[Fe^{2+}] = 68.46$ so $[Fe^{2+}] = 5.4 \times 10^{29}$ Give 1 mark out of 2 for either statement +1.13 V gives $\ln[Fe^{2+}] = 120.769$ so $[Fe^{2+}] = 2.81 \times 10^{52}$ Give 1 mark out of 2 for either statement Internal TE for this part can also be awarded if $\ln[Fe^{2+}]$ has a value and is correctly converted to $[Fe^{2+}]$. It is quite common to get $\ln[Fe^{2+}] = +0.769$ when $[Fe^{2+}] = 2.158 = 2.16$ is worth 1 mark	0.76	**2**

<table>
<tr><th>Question Number</th><th>Acceptable Answers</th><th>Reject</th><th>Mark</th></tr>
<tr><td>1(c)(i)</td><td>
<table>
<tr><th>Titration</th><th>Rough</th><th>1</th><th>2</th><th>3</th></tr>
<tr><td>Burette reading (final) / cm^3</td><td>25.00</td><td>24.40</td><td>24.40</td><td>25.70</td></tr>
<tr><td>Burette reading (initial) / cm^3</td><td>1.00</td><td>2.10</td><td>1.60</td><td>3.30</td></tr>
<tr><td>Titre /cm^3</td><td>24.(00)</td><td>22.3(0)</td><td>22.8(0)</td><td>22.4(0)</td></tr>
<tr><td>Titres used to calculate mean (✓)</td><td></td><td>✓</td><td></td><td>✓</td></tr>
</table>
All four titres correct

Note that the trailing zeroes are not essential (1)

Mean Titre 22.35 (cm^3) (1)

ALLOW TE on titres due to incorrect subtractions</td><td>22.40 / 22.4 / 22.50 / 22.875 (cm^3)</td><td>2</td></tr>
</table>

Question Number	Acceptable Answers	Reject	Mark
1(c)(ii)	Colourless to (first permanent pale) pink / purple **Both** colours required ALLOW Pale green / light green / green for colourless Pale yellow for colourless	Dark green	**1**

Question Number	Acceptable Answers	Reject	Mark
1(c)(iii)	$(MnO_4^- + 8H^+ + 5Fe^{2+}) \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+}$ $Mn^{2+} + 4H_2O$… **(1)** … $+ 5Fe^{3+}$ **(1)** But allow $+ 5e^{(-)}$ on either side of correct balanced equation for 1 max IGNORE state symbols even if incorrect	 $+ 5e^{(-)}$ alone	**2**

Question Number	Acceptable Answers	Reject	Mark
1(c)(iv)	mol MnO_4^- = 22.35 x 0.0300/1000 **(1)** = 6.705×10^{-4} mol Fe^{2+} = $6.705 \times 10^{-4} \times 5$ **(1)** = 3.353×10^{-3} $[Fe^{2+}]$ = $3.353 \times 10^{-3} \times 1000/25.0$ **(1)** = 0.1341 = **0.134** (mol dm^{-3}) **to 3 SF** **(1)** Correct answer with no working **(4)** Correct answer not to 3 sf with no working **(3)** ALLOW TE on mean titre in 2c(i) and equation in (iii) 22.5 gives 0.135 22.6 gives 0.136 Internal TEs should also be given if steps of the calculation are omitted. Some will multiply by 1000/22.35 in the last step to give 0.150 which is 3 out of 4 marks 0.15 would be 2 out of 4 marks		**4**

Question Number	Acceptable Answers	Reject	Mark
1(c)(v)	$\frac{(0.157 - \text{answer to 2c(iv)})}{0.157} \times 100$ Correct answer: $\frac{(0.157 - 0.134)}{0.157} \times 100$ = 14.6% IGNORE sf except 1 Some TEs from (iv): 0.135 gives 14.01% 0.136 gives 13.38% 0.150 gives 4.46%		**1**

Question Number	Acceptable Answers	Reject	Mark
1(c)(vi)	Pipette 0.06/25 x 100 = (±) 0.24% **(1)** Burette 0.10/22.35 x 100 = (±) 0.44743 = (±) 0.45% **(1)** ALLOW TE on titre in 2c(i) 22.5 gives = (±) 0.4444 = (±) 0.44% 22.6 gives = (±) 0.44248 = (±) 0.44% But 0.1/25 x 100 = 0.4 does not get a mark So 0.4 with **no working** gets no mark		**2**

Question Number	Acceptable Answers	Reject	Mark
1(c)(vii)	The apparatus error / combined errors is negligible compared to the difference (in concentration). ALLOW Percentage difference in value is bigger than percentage apparatus error. OR Percentage difference is greater than percentage error(s)	Just 'error of pipette is smaller than error of burette' Just 'apparatus error is small' '% error of apparatus is small so both pieces of apparatus are suitable' alone	**1**

Question Number	Acceptable Answers	Reject	Mark
1(c)(viii)	Fe^{2+} is (partially) oxidized (by air / oxygen) (on standing overnight) ALLOW Reverse argument OR iron/Fe (solution) is (partially) oxidized (by air / oxygen) (on standing overnight)	Absorbed moisture overnight so solution more dilute Incomplete reaction Transfer errors Impurities present	**1**

Total for Question 1 = 22 marks