Electrolysis, Electrode Potentials & Cells
Mark Scheme 6

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Electrochemistry
Sub-Topic	Electrolysis, Electrode Potentials & Cells
Paper Type	Theory
Booklet	Mark Scheme 6

Time Allowed: 64 minutes

Score: /53

Percentage: /100

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1 **(a)** $O_2 + 4H^+ + 4e^- \longrightarrow 2H_2O$ (or equation ÷ 2) **[1]**

(b) ⊕ **[1]**

(c) 1.23 (V) (ignore sign) **[1]**

(d) a better/larger salt bridge *or* a diaphragm *or* larger (area of) electrodes

or increase concentrations/pressure **[1]** 1

(e) time = 400 x 24 x 60 x 60 = 34 560 000 seconds **[1]**

charge = current x time = 0.01 x 34 560 000 = 345 600 C ecf **[1]**

moles of H = 345 600/96 500 = 3.6 mol ∴ mass of H = **3.6 g** ecf **[1]** 3

(f) advantages: less pollution/CO_2/NO_x etc. *or* cleaner by-products

less dependence on fossil fuels/finite resources *any one* **[1]**

disadvantages: more expensive (to develop *or* to run)

takes up more space

poor power-to-volume ratio

hydrogen is difficult to store or to transport *any one* **[1]**

NOT hydrogen is explosive/flammable **2**

Total 9

2 **(a)**   The EMF of a cell made up of the test electrode and a
<u>standard hydrogen electrode</u>.   [1]

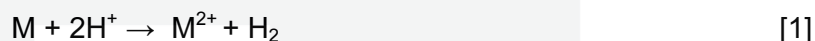EMF measured under standard conditions of T, P and concentration   [1]

2

(b) **(i)** $E_{left} = E_{right} - E_{cell}$ = 0.34 - 0.76   = **-0.42 (V)**   [1]

(ii) ⟶ (arrow from left to right)   [1]

(iii) I   pink/red solid/ppt *or* copper will be formed *or* blue solution
fades *or* M dissolves/corrodes   [1]

$Cu^{2+} + M \rightarrow Cu + M^{2+}$ [1]

II   hydrogen/gas evolved *or* M dissolves
(do not allow "M dissolves" for [2] marks in both I and II)   [1]

$M + 2H^+ \rightarrow M^{2+} + H_2$ [1]

6

(c) **(i)**   polarity of d. c. source: ⊖ is on the left, ⊕ is on the right   [1]

electrolyte is Cu^{2+}(aq)/$CuSO_4$/$CuCl_2$/$Cu(NO_3)_2$ etc. *or* name   [1]

(ii) moles of Cu = 0.5/63.5   = 7.87×10^{-3} [1]

moles of e^- = $2 \times 7.87 \times 10^{-3}$ = 1.57×10^{-2}

no. of coulombs = $96500 \times 1.57 \times 10^{-2}$ = 1517 (C)   [1]
ecf in n(e^-)

time = 1520/0.5   =   [1]
ecf in coulombs

5

Total 13

Question	Scheme	Mark	Total
3 **(a)**	<table><tr><th>name of particle</th><th>relative mass</th><th>relative charge</th></tr><tr><td>**proton**</td><td></td><td>**+**</td></tr><tr><td>**electron**</td><td>1/1836</td><td>**−**</td></tr><tr><td>**neutron**</td><td></td><td>**0**</td></tr></table>	[1] [1] [1]	[3]
(b) (i)	Mass of an atom(s) relative to $1/12^{th}$ (the mass) of (an atom of) carbon-12 **OR** relative to carbon-12 which is (exactly) 12	[1] [1]	[2]
(ii)	% of third isotope = 10 $$\frac{(24 \times 79) + (26 \times 11.0) + 10x}{100} = 24.3$$ 10x = 248 x = 24.8 (3s.f.)	[1] [1] [1]	[3]
(c) (i)	anode $\quad l^- \rightarrow Cl_2 + 2e^-$ cathode $\quad ^{2+} + 2e^- \rightarrow Mg$	[1] [1]	[2]
(ii)	$\begin{array}{cccc} Mg & O & H & Cl \\ \frac{31.65}{24.3} & \frac{20.84}{16} & \frac{1.31}{1} & \frac{46.2}{35.5} \\ \textbf{1.30} & \textbf{1.30} & & \end{array}$ MgOHCl	[1] [1]	[2]
(d) (i)	Na_2O basic/alkaline; Al_2O_3 amphoteric/acidic and basic; SO_3 acidic Na_2O (giant) ionic **AND** SO_3 (simple/molecular) covalent	[1] [1]	[2]
(ii)	$Na_2O + 2HCl \rightarrow 2NaCl + H_2O$ $Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + 3H_2O$ $Al_2O_3 + 2NaOH + 7H_2O \rightarrow 2NaAl(OH)_4(H_2O)_2$ **OR** $Al_2O_3 + 2NaOH + 3H_2O \rightarrow 2NaAl(OH)_4$ **OR** $Al_2O_3 + 2NaOH \rightarrow 2NaAlO_2 + H_2O$ **OR** $Al_2O_3 + 2OH^- + 7H_2O \rightarrow 2[Al(OH)_4(H_2O)_2]^-$ **OR** $Al_2O_3 + 2OH^- + 3H_2O \rightarrow 2[Al(OH)_4]^-$ **OR** $Al_2O_3 + 2OH^- \rightarrow 2AlO_2^- + H_2O$ $SO_3 + NaOH \rightarrow NaHSO_4$ **OR** $SO_3 + 2NaOH \rightarrow Na_2SO_4 + H_2O$	[1] [1] [1] [1]	[4]

4	(a	(i)	K_{sp} = [Ag$^+$(aq)]^2[SO$_4$$^{2-}$(aq)] **and** units: mol^{3}dm^{-9}	**1**
		(ii)	K_{sp} = (2 x 0.025)^2 x (0.025) = **6.25 x 10^{-5}**	**1**
	(b)			**1** **1** **1** **1**
	(c)	**(i)**	$E^\ominus_{cell}$ (= 0.80 – 0.77 =) (+)**0.03V and** Ag$^+$/Ag **or** Ag/silver **or** right	**1**
		(ii)	E_{cell} would be less positive/more negative because the [Ag$^+$(aq)] (in the Ag electrode) is less than 1.0 mol dm^{-3}	**1**
		(iii)	• no change	**1**
			• more negative/less positive	**1**
		(iv)	the [Ag$^+$(aq)] will decrease $E_{electrode}$ becomes less positive **or** due to the common ion effect	**1**
	(d)		[Fe^{3+}(aq)] = 0.2 mol dm^{-3}	**1**
			[H$^+$] = √(c.K$_a$) = √(0.2 x 8.9 x 10^{-4}) or 1.33 x 10^{-2} (mol dm^{-3}) pH = –log([H$^+$]) = **1.9** (or 1.87–1.89)	**1**
				[Total: 13]