

- M1.** (a) (i) Co/Cobalt
If Co or Cobalt not given CE = 0
ignore case in symbol for Co 1
- (+) 4 1
- (+) 3
Allow 4 and 3 in either order 1
- (ii) $\text{Li} \rightarrow \text{Li}^+ + \text{e}^-$
Ignore state symbols
Allow e without -ve sign
Do not allow equilibrium sign 1
- (iii) Platinum is a conductor 1
- (Platinum is) unreactive/inert
Ignore mention of surface area or catalyst
Allow 2 marks if two properties given on one answer line
Apply list principle to contradictions/wrong answers
Do not allow platinum resists corrosion 1
- (iv) Li reacts with water/forms lithium hydroxide
Allow water breaks down (or is electrolysed) on re-charge 1
- (b) (i) $\text{Pt} \mid \text{SO}_3^{2-}(\text{aq}), \text{SO}_4^{2-}(\text{aq}) \parallel \text{ClO}_3^-(\text{aq}), \text{Cl}^-(\text{aq}) \mid \text{Pt}$
State symbols as ', ' not necessary
Allow | in place of ', ' NOT ', ' in place of |
Ignore H⁺ and H₂O
Deduct one mark for each mistake (e.g. Pt missed twice counts as two mistakes)
Allow reverse order for whole cell



2



1

Oxidising agent ClO_3^-

1

Reducing agent SO_3^{2-}

1

[12]

M2. (a) Hydrogen/ H_2 gas/bubbles

1

1.0 mol dm^{-3} HCl/H^+

1

At 298K and 100kPa

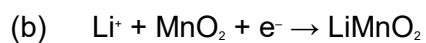
Allow 1 bar instead of 100 kPa

Do not allow 1 atm

1

Pt (electrode)

1



Ignore state symbols

1

-0.13(V)

1

(c) Fe^{3+} ions reduced to Fe^{2+}

Can score from equation/scheme

1

Because $E(\text{Fe}^{3+}/\text{Fe}^{2+}) > E(\text{H}^+/\text{H}_2)/E(\text{hydrogen})$

Allow emf/ E_{cell} +ve/0.77V

Allow Fe^{3+} better oxidising agent than H^+

*Allow H₂ better reducing agent than Fe²⁺
Only award this explanation mark if previous mark given*

1

(d) Moles Cr₂O₇²⁻ = $\frac{23.7 \times 0.01}{1000} = 2.37 \times 10^{-4}$

1

1 mol Cr₂O₇²⁻ reacts with 6 mol Fe²⁺ so moles
Fe²⁺ in 25 cm³ = $6 \times 2.37 \times 10^{-4} = 1.422 \times 10^{-3}$

1

M1 × 6

Moles Fe²⁺ in 250 cm³ = 1.422×10^{-2}

M2 × 10 or *M4/10*

1

Original moles Fe²⁺ = $\frac{10.00}{277.9} = 0.0360$

Independent mark

1

Moles Fe²⁺ oxidised = $0.0360 - 0.0142 = 0.0218$

M4 – *M3*

1

% oxidised = $(0.0218 \times 100)/0.0360 = 60.5\%$

(M5 × 100)/*M4*

Allow 60 to 61

Note Max 3 if mol ratio for M2 wrong

eg 1:5 gives 67.1%

1:1 gives 93.4%

Note also, 39.5% (39-40) scores M1, M2, M3 and M4 (4 marks)

1

[14]

M3. (a) By definition

allow 'set to this value'

1

(b) 1.23 V

Allow + or –

1

- (c) $\text{Pt}|\text{H}_2(\text{g})|\text{OH}^-(\text{aq}),\text{H}_2\text{O}(\text{l})||\text{O}_2(\text{g})|\text{H}_2\text{O}(\text{l}),\text{OH}^-(\text{aq})|\text{Pt}$
H₂O not essential, allow reverse order

Correct but with Pt missing

1

Includes Pt with correct representation

1

- (d) Uses $\text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^- \rightarrow 4\text{OH}^-$

And (2×) $2\text{OH}^- + \text{H}_2 \rightarrow 2\text{H}_2\text{O} + 2\text{e}^-$

1

$2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$

1

- (e) Increases the surface area (so reaction faster)

1

- (f) Overall reaction is the same ($2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$)
Or shows e.m.f. is the same

1

- (g) Hydrogen and oxygen supplied continuously

OR

Can be operated without stopping to recharge

Or can be refuelled quickly

Allow any one mark

1

- (h) Hydrogen may need to be made using an energy source that is not 'carbon neutral'

1

[10]

M4.(a) (Standard) hydrogen (electrode) (1)

1

(b) (i) To allow transfer of electrons / provide a reaction surface (1)

(ii) 298 K (1)

Both $\text{Fe}^{3+}(\text{aq})$ and $\text{Fe}^{2+}(\text{aq})$ have a concentration of 1
 mol dm^{-3} (1) (QoL)

OR $[\text{H}^+] = 1 \text{ mol dm}^{-3}$

NOT zero current or 100 kPa

3

(c) +1.34 V (1)



Correct species / order (1)

Balanced and cancelled (1)

Allow one for $2 \text{MnO}_4^- + 5 \text{H}_2\text{SO}_3 \rightarrow 2 \text{Mn}^{2+} + 5 \text{SO}_4^{2-}$

3

(d) (i) $\text{Ce}^{4+}(\text{aq})$ (1)

(ii) $\text{VO}_2^+(\text{aq})$ (1); Cl_2 (1)

Penalise additional answers to zero

3

(e) Pt | $\text{Fe}^{2+}(\text{aq})$, $\text{Fe}^{3+}(\text{aq})$ || $\text{Ce}^{4+}(\text{aq})$, $\text{Ce}^{3+}(\text{aq})$ | Pt

Correct species (1)

Correct order (1)

Deduct one mark for each error

2

[12]