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) Li → Li⁺ + 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) <u>Li</u> reacts with <u>water</u>/forms lithium hydroxide

Allow water breaks down (or is electrolysed) on re-charge

1

(b) (i) Pt│SO₃²⁻ (aq), SO₄²⁻ (aq)│ │ClO₃⁻ (aq), Cl⁻(aq)│ Pt

State symbols an ',' 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

Page 2

$$Pt \mid Cl^-, ClO_3^- \parallel SO_4^{2-}, SO_3^{2-} \mid Pt$$

2
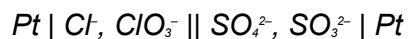
    (ii) $ClO_3^- + 3SO_3^{2-} \rightarrow Cl^- + 3SO_4^{2-}$

1

        Oxidising agent ClO_3^-

1

        Reducing agent SO_3^{2-}

1

[12]

M2.   (a)   Hydrogen/H_2 <u>gas/bubbles</u>

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
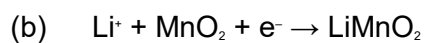
    (b) $Li^+ + MnO_2 + e^- \rightarrow LiMnO_2$
> *Ignore state symbols*

1

        -0.13(V)

1

    (c) Fe^{3+} ions reduced to Fe^{2+}
> *Can score from equation/scheme*

1

        Because $E(Fe^{3+}(/Fe^{2+})) > E(H^+/H_2)/E$(hydrogen)
> *Allow emf/E_{cell} +ve/0.77V*
> *Allow Fe^{3+} better oxidising agent than H^+*

Allow H_2 better reducing agent than Fe^{2+}
Only award this explanation mark if previous mark given

1

(d)   Moles $Cr_2O_7^{2-}$ =<u>23.7 × 0.01/1000</u> = $2.37 × 10^{-4}$

1

1 mol $Cr_2O_7^{2-}$ reacts with 6 mol Fe^{2+} so moles
Fe^{2+} in 25 cm^3 = 6 × $2.37 × 10^{-4}$ = $1.422 × 10^{-3}$

1

M1 × 6

Moles Fe^{2+} in 250 cm^3 = $1.422 × 10^{-2}$
M2 × 10 or M4/10

1

Original moles Fe^{2+} = <u>10.00/277.9</u> = 0.0360
Independent mark

1

Moles Fe^{2+} oxidised = 0.0360 – 0.0142 = 0.0218
M4 – M3

1

% oxidised = (0.0218 × 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) $Pt|H_2(g)|OH^-(aq),H_2O(l)||O_2(g)|H_2O(l),OH^-(aq)|Pt$
      H_2O not essential, allow reverse order

Correct but with Pt missing

1

Includes Pt with correct representation

1

(d) Uses $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$

And (2×) $2OH^- + H_2 \rightarrow 2H_2O + 2e^-$

1

$2H_2 + O_2 \rightarrow 2H_2O$

1

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

1

(f) Overall reaction is the same ($2H_2 + O_2 \rightarrow 2H_2O$)
      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]

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

1

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

          (ii)   298 K **(1)**
                  <u>Both Fe^{3+} (aq) and Fe^{2+} (aq)</u> have a concentration of 1
                  mol dm^{-3} **(1)** (QoL)
                  OR $[H^+]$ = 1 mol dm^{-3}
                          NOT zero current or 100 kPa

3

   (c)   +1.34 V **(1)**
          $2 MnO_4^- + 5 H_2SO_3 \rightarrow 2 Mn^{2+} + 5 SO_4^{2-} + 3 H_2O + 4 H^+$
          Correct species / order **(1)**
          Balanced and cancelled **(1)**
                  Allow one for $2 MnO_4^- + 5 H_2SO_3 \rightarrow 2 Mn^{2+} + 5 SO_4^{2-}$

3

   (d)   (i) Ce^{4+} (aq) **(1)**

          (ii) VO_2^+ (aq) **(1)**; Cl_2 **(1)**
                  Penalise additional answers to zero

3

   (e)   Pt | Fe^{2+} (aq), Fe^{3+} (aq) || Ce^{4+}(aq), Ce^{3+} (aq) | Pt
          Correct species **(1)**
          Correct order **(1)**
                  Deduct one mark for each error

2

                                                                              [12]