M1. (a) most powerful reducing agent: Zn;

1

(b) (i) reducing species: Fe^{2+}

1

(ii) oxidising species: Cl_2;

1

(c) (i) standard electrode potential 1.25 V;

1

(ii) equation: $Tl^{3+} + 2\ Fe^{2+} \rightarrow 2Fe^{3+} + Tl +$ balanced;

1

correct direction;

1

(d) (i) moles $KMnO_4 = 16.2 \times 0.0200 \times 10^{-3} = 3.24 \times 10^{-4}$;

1

moles H_2O_2 = Moles $KMnO_4 \times 5 / 2 = 8.10 \times {}^{-4}$;

1

8.10×10^{-4} moles H_2O_2 in 25 cm^3
$8.10 \times 10^{-4} \times 1000 / 25$ in 1000 $cm^3 = 0.0324$ mol dm^{-3};

1

hence g dm^{-3} = mol $dm^{-3} \times M_r = 0.0324 \times 34 = 1.10$;
(penalise use of an incorrect H_2O_2 to $KMnO_4$ ratio by two marks)

1

(ii) $PV = nRT$;

1

hence $V = nRT / P$
$= 8.10 \times 10^{-4} \times 8.31 \times 298/98000$;

1

$= 2.05 \times 10^{-5}$;

1

units m^3;

(mark consequentially to answers in (c)(i))
(allow correct answers with other units)
(answers to (c)(i) and (ii) must be to 3 significant figures; penalise once only)

1

[14]

M2. (a) *Cell e.m.f.*: 1.93 (v) CE if negative value given **(1)**

Half equation: $Mg \rightarrow Mg^{2+} + 2\ e^-$ **(1)**

or ⇌

Ignore state symbols

Mark on after an AE

2

(b) *Change in e.m.f.*: increases **(1)**

Mark on even if incorrect

Explanation: Equilibrium displaced to Mg^{2+} or to the left **(1)**

cell reaction or overall reaction goes to the right
Electrode is more negative or E decreases
or gives more electron
or forms more Mg^{2+} ions
Mark separately

3

(c) *Cell e.m.f.* : –0.84 (V) **(1)**

Explanation: Fe is giving electrons **or** forming Fe^{2+}
or reaction goes in the reverse direction **(1)**

Mark on after AE

N.B. In (a) and (c) mark on if no value given, but CE in both (a) and (c) if e.m.f. = 0

2

[7]

M3.(a) (Standard) hydrogen (electrode) **(1)**

1

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

(ii) 298 K **(1)**
Both F^{3+} (aq) and Fe^{2+} (aq) 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]

M4.D

[1]

M5.C

[1]

M6. C

[1]

M7. (a) *Hydrogen ion concentration*: 1.00 mol dm^{-3} **(1)**

Hydrogen gas pressure: 100 kPa **(1)**

2

(b) *Explanation of change*: Equilibrium displaced to left **(1)**
to reduce constraint **(1)**

Change in electrode potential: Becomes negative or decreases **(1)**
allow more negative

3

(c) (i) 0.43V **(1)**

(ii) *Half-equation*: $2Br^- \rightarrow Br_2 + 2e^-$ **(1)**

Overall equation: $2BrO_3^- + 10Br^- + 12H^+ \rightarrow 6Br_2 + 6H_2O$ **(2)**
or $BrO_3^- + 5Br^- + 6H^+ \rightarrow 3Br_2 + 3H_2O$

*species **(1)***
*balanced **(1)***

4

[9]

M8. D

[1]

M9. B

[1]