

- M1.** (a) most powerful reducing agent: Zn; 1
- (b) (i) reducing species: Fe<sup>2+</sup> 1
- (ii) oxidising species: Cl<sub>2</sub>; 1
- (c) (i) standard electrode potential 1.25 V; 1
- (ii) equation:  $\text{Ti}^{3+} + 2 \text{Fe}^{2+} \rightarrow 2\text{Fe}^{3+} + \text{Ti}$  + balanced; 1
- correct direction; 1
- (d) (i) moles  $\text{KMnO}_4 = 16.2 \times 0.0200 \times 10^{-3} = 3.24 \times 10^{-4}$ ; 1
- moles  $\text{H}_2\text{O}_2 = \text{Moles KMnO}_4 \times 5 / 2 = 8.10 \times 10^{-4}$ ; 1
- $8.10 \times 10^{-4}$  moles  $\text{H}_2\text{O}_2$  in 25 cm<sup>3</sup>  
 $8.10 \times 10^{-4} \times 1000 / 25$  in 1000 cm<sup>3</sup> = 0.0324 mol dm<sup>-3</sup>; 1
- hence g dm<sup>-3</sup> = mol dm<sup>-3</sup> ×  $M_r$  = 0.0324 × 34 = 1.10;  
*(penalise use of an incorrect H<sub>2</sub>O<sub>2</sub> to KMnO<sub>4</sub> 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<sup>3</sup>;

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

or  $\rightleftharpoons$

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  $\text{Mg}^{2+}$  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  $\text{Mg}^{2+}$  ions  
Mark separately

3

- (c) Cell e.m.f. : -0.84 (V) **(1)**

*Explanation:* Fe is giving electrons or forming  $\text{Fe}^{2+}$   
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  $\text{F}^{3+}(\text{aq})$  and  $\text{Fe}^{2+}(\text{aq})$  have a concentration of 1  
 $\text{mol dm}^{-3}$  **(1)** (QoL)

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

*NOT zero current or 100 kPa*

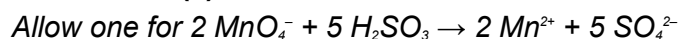
3

(c) +1.34 V **(1)**



Correct species / order **(1)**

Balanced and cancelled **(1)**



3

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

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

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**M4.D**

[1]

**M5.C**

[1]

**M6.C**

[1]

**M7.** (a) *Hydrogen ion concentration:* 1.00 mol dm<sup>-3</sup> **(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:*  $2\text{Br}^- \rightarrow \text{Br}_2 + 2\text{e}^-$  **(1)**

*Overall equation:*  $2\text{BrO}_3^- + 10\text{Br}^- + 12\text{H}^+ \rightarrow 6\text{Br}_2 + 6\text{H}_2\text{O}$  **(2)**  
or  $\text{BrO}_3^- + 5\text{Br}^- + 6\text{H}^+ \rightarrow 3\text{Br}_2 + 3\text{H}_2\text{O}$

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

4

[9]

**M8.D**

[1]

**M9.B**

[1]

