

M1.(a) Manganate would oxidise / react with Cl<sup>-</sup>

1

Because  $E^\ominus$  for  $\text{MnO}_4^-$  is more positive than that for  $\text{Cl}^-$  /  $1.51 - 1.36 = +0.15$   
(V)

*Must refer to data from the table for M2.*

1

(b) Moles of  $\text{H}^+$  =  $25 \times 0.0200 \times 8 / 1000 = 4.00 \times 10^{-3}$

1

Moles of  $\text{H}_2\text{SO}_4 = 2.00 \times 10^{-3}$  ( $4.00 \times 10^{-3} / 2$ )

*Allow consequential marking on incorrect moles of  $\text{H}^+$*

1

Volume  $\text{H}_2\text{SO}_4 = 4.00$  ( $\text{cm}^3$ ) ( $2.00 \times 10^{-3} \times 1000 / 0.500$ )

*Allow consequential marking on incorrect moles of  $\text{H}_2\text{SO}_4$*

*Accept  $4 \text{ cm}^3$ .*

*$8 \text{ cm}^3$  scores 2 marks.*

*Do not penalise precision.*

*Correct answer without working scores M3 only.*

1

(c) (i)  $\text{MnO}_4^- + 4\text{H}^+ + 3\text{e}^- \rightarrow \text{MnO}_2 + 2\text{H}_2\text{O}$

*Allow multiples, including fractions.*

*Ignore state symbols.*

1

(ii) Can't see end point due to brown colour

1

Larger titre (than expected)

*Allow the idea that with two reactions can't make use of titre in calculations.*

*Do not allow 'an inaccurate result' without qualification.*

1

(d) Solution (very) dilute / lots of water

1

[9]

**M2.**  $\text{MnO}_4^-$  will oxidise the chloride ion / reaction of  $\text{MnO}_4^-$  and  $\text{Cl}^-$  feasible

*Accept converse argument with  $\text{Cr}_2\text{O}_7^{2-}$*

*Accept calculations of overall  $E^\circ$  values.*

1

Larger volume needed

1

[2]

**M3.** (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)  $\text{Pt} | \text{SO}_3^{2-} (\text{aq}), \text{SO}_4^{2-} (\text{aq}) || \text{ClO}_3^- (\text{aq}), \text{Cl}^- (\text{aq}) | \text{Pt}$

*State symbols as ', ' not necessary*

*Allow | in place of ', ' NOT ', ' in place of |*

*Ignore H<sup>+</sup> and H<sub>2</sub>O*

*Deduct one mark for each mistake (e.g. Pt missed twice counts as two mistakes)*

*Allow reverse order for whole cell*

*Pt | Cl<sup>-</sup>, ClO<sub>3</sub><sup>-</sup> || SO<sub>4</sub><sup>2-</sup>, SO<sub>3</sub><sup>2-</sup> | Pt*

2

(ii)  $\text{ClO}_3^- + 3\text{SO}_3^{2-} \rightarrow \text{Cl}^- + 3\text{SO}_4^{2-}$

1

Oxidising agent  $\text{ClO}_3^-$

1

Reducing agent  $\text{SO}_3^{2-}$

1

[12]

**M4.(a)** HCl 1.0 mol dm<sup>-3</sup>

*Allow H<sub>2</sub>SO<sub>4</sub> 0.5 mol dm<sup>-3</sup>*

*Allow HNO<sub>3</sub> 1.0 mol dm<sup>-3</sup>*

*Allow name or formula*

*Concentration can be given after "conditions"*

1

(Hydrogen at) 100kPa / 1 bar 1

298 K 1

(b) Pt / Platinum  
*Mark on if no answer for M1*  
*If wrong answer for M1, only mark on if electrode is Au, Ag, Pb or Ti* 1

Inert / unreactive / does not create a potential difference 1

Conducts electricity / allows electron flow / conducts / conductor 1

(c) KCl  
*Allow NaCl, KNO<sub>3</sub>, Na<sub>2</sub>SO<sub>4</sub> etc NOT NH<sub>4</sub>Cl* 1

Does not react with either electrode / solution in electrode  
*Allow unreactive / inert* 1

Ions can move  
*Allow conducts electricity / electrical connection / carries charge*  
*Do not allow just connects / completes the circuit*  
*Do not allow conducts / carries electrons*  
*Mark these independently* 1

(d)  $\text{Pt}|\text{H}_2|\text{H}^+||\text{Fe}^{3+},\text{Fe}^{2+}|\text{Pt}$   
*Ignore state symbols*  
*Order must be correct*  
*| must be correct but allow | instead of , separating  $\text{Fe}^{3+}$  from  $\text{Fe}^{2+}$*   
*Allow , instead of | separating  $\text{H}_2$  and  $\text{H}^+$*  1

(e) (i)  $2\text{Fe}^{3+} + \text{H}_2 \rightarrow 2\text{Fe}^{2+} + 2\text{H}^+$   
*Allow multiples* 1

(ii) The  $\text{Fe}^{3+}$  ions would be used up / reaction completed  
*Answer must relate to reactants in (e)(i) equation if given*  
*Allow reactant / reactants used up*  
*Do not allow concentration of  $\text{Fe}^{3+}$  decreases*  
*Allow concentration of  $\text{Fe}^{3+}$  falls to zero* 1

[12]

**M5.(a)** loses electrons / donates electrons  
*penalise donates electron pair* 1

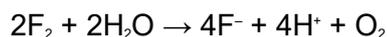
(b) Zn 1

(most) negative  $E^\circ$  / lowest  $E^\circ$  / least positive  
*can only score M2 if M1 correct*  
*do not allow e.m.f instead of  $E^\circ$*  1

(c)  $E^\circ \text{F}_2 / (\text{F}^-) > E^\circ \text{O}_2 / (\text{H}_2\text{O})$   
*or e.m.f is positive or e.m.f = 1.64 V* 1

Fluorine reacts to form oxygen (can score from equation in M3 even if equation unbalanced provided no contradiction)  
 or fluorine oxidises water  
 or fluorine is a more powerful oxidising agent than oxygen

1



*allow 4HF in equation*

*balanced equation scores M2 and M3*

1

- (d) (i) order correct Zn Zn<sup>2+</sup> Ag<sub>2</sub>O Ag or reverse of this order  
*ignore ss , H<sup>+</sup> and H<sub>2</sub>O, no. of moles*

1

*all phase boundaries correct*

*allow Zn|Zn<sup>2+</sup>||Ag<sub>2</sub>O,Ag*

*or Zn|Zn<sup>2+</sup>||Ag<sub>2</sub>O|H<sup>+</sup>|Ag for M1 & M2*

*e.g. Zn|Zn<sup>2+</sup>||Ag<sub>2</sub>O|Ag or Ag|Ag<sub>2</sub>O||Zn<sup>2+</sup>|Zn scores 2*

*M2 cannot be gained unless M1 scored*

*allow H<sup>+</sup> either side of Ag<sub>2</sub>O with comma or |*

*for M2 penalise*

- wrong phase boundary (allow dashed lines for salt bridge)*
- Pt*
- use of + (from half equation)*
- water/H<sup>+</sup> outside Ag in Ag electrode*

1

- (ii) 1.1 (V)

*Allow no units, penalise wrong units*

*allow correct answer even if no answer to (d)(i) or answer to (d)(i) incorrect*

*allow -1.1 if silver electrode on Left in (d)(i) even if the species are in the wrong order.*

1

- (iii) Reaction(s) not reversible or H<sub>2</sub>O electrolyses

*do not allow hard to reverse*

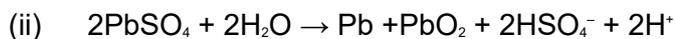
*mention of primary cell is not enough to show that reaction(s) are irreversible*

1

- (e) (i) -0.46 (V)

*Allow no units, penalise wrong units*

1



lead species correct on correct sides of equation

1

equation balanced and includes  $\text{H}_2\text{O}$ ,

$\text{HSO}_4^-$  and  $\text{H}^+$  (or  $\text{H}_2\text{SO}_4$ )

*allow ions / species must be fully cancelled out or combined*

*allow 1/2 for balanced reverse equation*

1

- (f) (i) reagents /  $\text{PbO}_2$  /  $\text{H}_2\text{SO}_4$  / acid / ions used up  
(or concentration decreases)

1

- (ii) fuel cell

*Ignore any other words*

1

- (iii) reagents / fuel supplied continuously

1

concentrations (of reagents) remain constant

1

[17]

**M6.(a)**  $\text{H}_2\text{O}_2$

*Ignore state symbols*

1

- (b)  $E^\ominus \text{Cl}_2/\text{Cl}^- > E^\ominus \text{O}_2/\text{H}_2\text{O}$

*Allow potential for chlorine/ $\text{Cl}_2$  greater than for oxygen/ $\text{O}_2$*

*Allow  $1.36 > 1.23$  /  $E_{\text{cell}} = 0.13$*

1



*Allow multiples*

*Allow + HCl*

1

- (c) Activation energy is high / light/UV provides the activation energy / light breaks

chlorine molecule / Cl–Cl bond

*If light used to break Cl–Cl bond award 1 mark and ignore product e.g. Cl<sup>-</sup>*

1

(d) O (-1) (in H<sub>2</sub>O<sub>2</sub>)

*Must give oxidation state of O in H<sub>2</sub>O<sub>2</sub> = -1*

1

Changes to O(-2) (in water)

*Must give oxidation state of O in water = -2*

*CE = 0/2 if refers to oxidation state of H changing*

1

(e)  $E^\ominus \text{H}_2\text{O}_2/\text{H}_2\text{O} > E^\ominus \text{O}_2/\text{H}_2\text{O}_2$

*Allow stated in words*

*Allow 1.77 > 0.68 / E cell = 1.09*

1



*Allow multiples*

*H<sup>+</sup> and e<sup>-</sup> must be cancelled*

1

[8]