M1.(a) Manganate would oxidise / react with $\underline{Cl^-}$

1

Because $E^{\ominus}$ for MnO_4^- is more positive than that for Cl^2 / 1.51 – 1.36 = +0.15 (V)

Must refer to data from the table for M2.

1

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

1

Moles of $H_2SO_4 = 2.00 \times 10^{-3}$ ($4.00 \times 10^{-3} / 2$)

Allow consequential marking on incorrect moles of H^+

1

Volume H_2SO_4 = 4.00 (cm^3) ($2.00 \times 10^{-3} \times 1000 / 0.500$)

Allow consequential marking on incorrect moles of H_2SO_4
Accept 4 cm^3.
8 cm^3 scores 2 marks.
Do not penalise precision.
Correct answer without working scores M3 only.

1

(c) (i) $MnO_4^- + 4H^+ + 3e^- \rightarrow MnO_2 + 2H_2O$

Allow multiples, including fractions.
Ignore state symbols.

1

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

1

$\underline{Larger}$ 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. MnO_4^- will oxidise the chloride ion / reaction of MnO_4^- and Cl^- feasible

Accept converse argument with $Cr_2O_7^{2-}$

Accept calculations of overall E° 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) $Li \rightarrow Li^+ + e^-$

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) Li reacts with water/forms lithium hydroxide

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

1

(b) (i) $Pt \mid SO_3^{2-}(aq), SO_4^{2-}(aq) \mid\mid ClO_3^-(aq), Cl^-(aq) \mid Pt$

State symbols an ',' not necessary

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

Ignore H^+ and H_2O

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

Allow reverse order for whole cell

Pt | Cl^-, ClO_3^- || SO_4^{2-}, SO_3^{2-} | 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]

M4.(a) HCl 1.0 mol dm^{-3}

Allow H_2SO_4 0.5 mol dm^{-3}

Allow HNO_3 1.0 mol dm^{-3}

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_3, Na_2SO_4 etc NOT NH_4Cl

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) $Pt|H_2|H^+||Fe^{3+},Fe^{2+}|Pt$

Ignore state symbols

Order must be correct

| must be correct but allow | instead of , separating Fe^{3+} from Fe^{2+}

Allow , instead of | separating H_2 and H^+

1

(e) (i) $2Fe^{3+} + H_2 \longrightarrow 2Fe^{2+} + 2H^+$

Allow multiples

1

(ii) The $\underline{Fe}^{3+}$ 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 Fe^{3+} decreases

Allow concentration of Fe^{3+} falls to zero

1

[12]

M5.(a) loses electrons / donates electrons

penalise donates electron pair

1

(b) Zn

1

(most) negative E° / lowest E° / least positive

can only score M2 if M1 correct

do not allow e.m.f instead of E°

1

(c) $\underline{E^\circ F_2}$ ($/F^-$) > $\underline{E^\circ O_2}$ ($/H_2O$)

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

$2F_2 + 2H_2O \rightarrow 4F^- + 4H^+ + O_2$

allow 4HF in equation

balanced equation scores M2 and M3

1

(d) (i) order correct Zn Zn^{2+} Ag_2O Ag or reverse of this order

ignore ss , H^+ and H_2O, no. of moles

1

all phase boundaries correct

allow Zn|Zn^{2+}||Ag_2O,Ag

or Zn|Zn^{2+}||Ag_2O|H^+|Ag for M1 & M2

e.g. Zn|Zn^{2+}||Ag_2O|Ag or Ag|Ag_2O||Zn^{2+}|Zn scores 2

M2 cannot be gained unless M1 scored

allow H^+ either side of Ag_2O with comma or |

for M2 penalise

- *wrong phase boundary (allow dashed lines for salt bridge)*
- *Pt*
- *use of + (from half equation)*
- *water/H^+ 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_2O 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

(ii) $2PbSO_4 + 2H_2O \rightarrow Pb + PbO_2 + 2HSO_4^- + 2H^+$

lead species correct on correct sides of equation

1

equation balanced and includes H_2O,

HSO_4^- and H+ (or H_2SO_4)

allow ions / species must be fully cancelled out or combined

allow 1/2 for balanced reverse equation

1

(f) (i) reagents / PbO_2 / H_2SO_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) H_2O_2

Ignore state symbols

1

(b) $E^\ominus Cl_2/Cl^- > E^\ominus O_2/H_2O$

Allow potential for chlorine/Cl_2 greater than for oxygen/O_2

Allow 1.36 > 1.23 / E cell = 0.13

1

$Cl_2 + H_2O \longrightarrow 2Cl^- + 1/2O_2 + 2H^+$

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^-

1

(d) O (–1) (in H_2O_2)

Must give oxidation state of O in H_2O_2= –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) $E^{\ominus}$ H_2O_2/H_2O > $E^{\ominus}$ O_2/H_2O_2

Allow stated in words

Allow 1.77 > 0.68 / E cell = 1.09

1

$2H_2O_2 \rightarrow O_2 + 2H_2O$

Allow multiples

H^+ and e^- must be cancelled

1

[8]