

M1.(a) Manganate would oxidise / react with Cl⁻

1

Because E^\ominus for MnO_4^- is more positive than that for Cl^- / $1.51 - 1.36 = +0.15$
(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 $\text{H}_2\text{SO}_4 = 2.00 \times 10^{-3}$ ($4.00 \times 10^{-3} / 2$)

Allow consequential marking on incorrect moles of H^+

1

Volume $\text{H}_2\text{SO}_4 = 4.00$ (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) $\text{MnO}_4^- + 4\text{H}^+ + 3\text{e}^- \rightarrow \text{MnO}_2 + 2\text{H}_2\text{O}$

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. MnO_4^- will oxidise the chloride ion / reaction of MnO_4^- and Cl^- feasible

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

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) $\text{Li} \rightarrow \text{Li}^+ + \text{e}^-$

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⁺ and H₂O

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

Allow reverse order for whole cell

Pt | Cl⁻, ClO₃⁻ || SO₄²⁻, SO₃²⁻ | Pt

2

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

1

Oxidising agent ClO_3^-

1

Reducing agent SO_3^{2-}

1

[12]

M4.(a) HCl 1.0 mol dm⁻³

Allow H₂SO₄ 0.5 mol dm⁻³

Allow HNO₃ 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, KNO₃, Na₂SO₄ etc NOT NH₄Cl 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 Fe^{3+} from Fe^{2+}
Allow , instead of | separating H_2 and H^+ 1

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

(ii) The 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

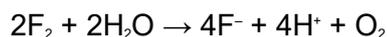
(b) Zn 1

(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) $E^\circ \text{F}_2 (\text{F}^-) > E^\circ \text{O}_2 (\text{H}_2\text{O})$
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 Zn²⁺ Ag₂O Ag or reverse of this order
ignore ss, H⁺ and H₂O, no. of moles

1

all phase boundaries correct

allow Zn|Zn²⁺||Ag₂O,Ag

or Zn|Zn²⁺||Ag₂O|H⁺|Ag for M1 & M2

e.g. Zn|Zn²⁺||Ag₂O|Ag or Ag|Ag₂O||Zn²⁺|Zn scores 2

M2 cannot be gained unless M1 scored

allow H⁺ either side of Ag₂O 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 H₂O electrolyses

do not allow hard to reverse

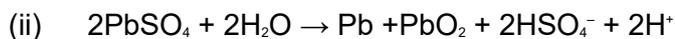
mention of primary cell is not enough to show that reaction(s) are irreversible

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

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

1

(d) O (-1) (in H₂O₂)

Must give oxidation state of O in H₂O₂ = -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⁺ and e⁻ must be cancelled

1

[8]