

Mark schemes

1

- (a) Manganate would oxidise / react with 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 $\text{H}_2\text{SO}_4 = 2.00 \times 10^{-3}$ ($4.00 \times 10^{-3} / 2$)

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

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2

- (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) 100 kPa / 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) Pt|H₂|H⁺||Fe³⁺,Fe²⁺|Pt

Ignore state symbols

Order must be correct

| must be correct but allow | instead of , separating Fe³⁺ from Fe²⁺

Allow , instead of | separating H₂ 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 Fe³⁺ 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 Fe³⁺ decreases

Allow concentration of Fe³⁺ falls to zero

1

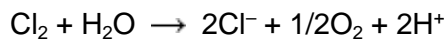
[12]

3(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 H_2O_2)*Must give oxidation state of O in $\text{H}_2\text{O}_2 = -1$*

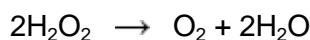
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Changes to O (-2) (in water)*Must give oxidation state of O in water = -2**CE = 0/2 if refers to oxidation state of H changing*

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 $1.77 > 0.68$ / $E_{\text{cell}} = 1.09$*

1

*Allow multiples* *H^+ and e^- must be cancelled*

1

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4

(a) loses electrons / donates electrons
penalise donates electron pair 1

(b) Zn 1

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

(c) $E^\ominus F_2 (F^-) > E^\ominus O_2 (H_2O)$
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 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
- (ii) $2\text{PbSO}_4 + 2\text{H}_2\text{O} \rightarrow \text{Pb} + \text{PbO}_2 + 2\text{HSO}_4^- + 2\text{H}^+$
 lead species correct on correct sides of equation 1
 equation balanced and includes H₂O,
 HSO₄⁻ and H⁺ (or H₂SO₄)
allow ions / species must be fully cancelled out or combined
allow 1/2 for balanced reverse equation 1
- (f) (i) reagents / PbO₂ / H₂SO₄ / 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]

5

MnO₄⁻ will oxidise the chloride ion / reaction of MnO₄⁻ and Cl⁻ feasible

Accept converse argument with Cr₂O₇²⁻

Accept calculations of overall E° values.

1

6

- (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 H_2O
Deduct one mark for each mistake (e.g. Pt missed twice counts as two mistakes)
Allow reverse order for whole cell
 $\text{Pt} | \text{Cl}^-, \text{ClO}_3^- || \text{SO}_4^{2-}, \text{SO}_3^{2-} | \text{Pt}$ 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]

7

- (a) Hydrogen/ H_2 gas/bubbles 1
- 1.0 mol dm^{-3} HCl/ H^+ 1
- At 298K and 100kPa
Allow 1 bar instead of 100 kPa
Do not allow 1 atm 1
- Pt (electrode) 1
- (b) $\text{Li}^+ + \text{MnO}_2 + \text{e}^- \rightarrow \text{LiMnO}_2$
Ignore state symbols 1
- 0.13(V) 1
- (c) Fe^{3+} ions reduced to Fe^{2+}
Can score from equation/scheme 1
- Because $E(\text{Fe}^{3+}/\text{Fe}^{2+}) > E(\text{H}^+/\text{H}_2)/E(\text{hydrogen})$
Allow emf/ E_{cell} +ve/0.77V
Allow Fe^{3+} better oxidising agent than H^+
Allow H_2 better reducing agent than Fe^{2+}
Only award this explanation mark if previous mark given 1

(d) Moles $\text{Cr}_2\text{O}_7^{2-} = \underline{23.7 \times 0.01/1000} = 2.37 \times 10^{-4}$

1

1 mol $\text{Cr}_2\text{O}_7^{2-}$ reacts with 6 mol Fe^{2+} so moles
 Fe^{2+} in $25 \text{ cm}^3 = 6 \times 2.37 \times 10^{-4} = 1.422 \times 10^{-3}$

1

$M1 \times 6$

Moles Fe^{2+} in $250 \text{ cm}^3 = 1.422 \times 10^{-2}$

$M2 \times 10$ or $M4/10$

1

Original moles $\text{Fe}^{2+} = \underline{10.00/277.9} = 0.0360$

Independent mark

1

Moles Fe^{2+} oxidised = $0.0360 - 0.0142 = 0.0218$

$M4 - M3$

1

% oxidised = $(0.0218 \times 100)/0.0360 = 60.5\%$

$(M5 \times 100)/M4$

Allow 60 to 61

Note Max 3 if mol ratio for M2 wrong

eg 1:5 gives 67.1%

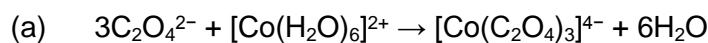
1:1 gives 93.4%

Note also, 39.5% (39-40) scores M1, M2, M3 and M4 (4 marks)

1

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8



Accept multiples.

Equation must have cobalt(II) hexaaqua ion.

1

(b) Ethanedioate ion reduces iron(III) ion **or**
iron(III) ion oxidises ethanedioate ion

Allow answer using equations.

1

E^\ominus ($\text{CO}_2 / \text{C}_2\text{O}_4^{2-}$) more negative than E^\ominus ($\text{Fe}^{3+} / \text{Fe}^{2+}$) **or**

E^\ominus ($\text{Fe}^{3+} / \text{Fe}^{2+}$) $>$ E^\ominus ($\text{CO}_2 / \text{C}_2\text{O}_4^{2-}$)

or e.m.f. positive **or** cell voltage = +1.26

1

[3]

