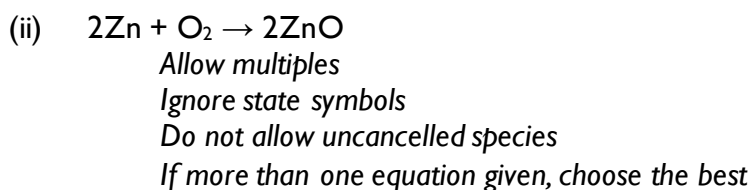


Electrode Potentials & Cells Test Answers

- I. (a) (i) 0.60 V 1
- (ii) $\text{H}_2\text{O} + \text{H}_2\text{SO}_3 \rightarrow \text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^-$ 1
- (b) (i) $2\text{IO}_3^- + 2\text{H}^+ + 5\text{H}_2\text{O}_2 \rightarrow 5\text{O}_2 + \text{I}_2 + 6\text{H}_2\text{O}$ Species 1
- Balanced 1
- (ii) The concentration of the ions change or are no longer standard or the e.m.f is determined when no current flows 1
- (iii) Unchanged 1
- (iv) Increased 1
- Equilibrium IO_3^-/I_2 displaced to the right 1
- Electrons more readily accepted or more reduction occurs or electrode becomes more positive (Q o L) 1
- (c) VO_2^+ 1
- 5 or V 1
- $\text{V}^{2+} + 2\text{H}_2\text{O} \rightarrow \text{VO}_2^+ + 4\text{H}^+ + 3\text{e}^-$ 1
- [12]**
2. (a) (Standard) hydrogen (electrode) (1) 1
- (b) (i) To allow transfer of electrons / provide a reaction surface (1) 1
- (ii) 298 K (1) 1
- Both $\text{Fe}^{3+}(\text{aq})$ and $\text{Fe}^{2+}(\text{aq})$ have a concentration of 1 1
- mol dm⁻³ (1) (QoL) 1
- OR $[\text{H}^+] = 1 \text{ mol dm}^{-3}$ 1
- NOT zero current or 100 kPa 3
- (c) +1.34 V (1) 1
- $2 \text{MnO}_4^- + 5 \text{H}_2\text{SO}_3 \rightarrow 2 \text{Mn}^{2+} + 5 \text{SO}_4^{2-} + 3 \text{H}_2\text{O} + 4 \text{H}^+$ 1
- Correct species / order (1) 1
- Balanced and cancelled (1) 1
- Allow one for $2 \text{MnO}_4^- + 5 \text{H}_2\text{SO}_3 \rightarrow 2 \text{Mn}^{2+} + 5 \text{SO}_4^{2-}$ 3
- (d) (i) $\text{Ce}^{4+}(\text{aq})$ (1) 3

- (ii) VO_2^+ (aq) (1); Cl_2 (1)
 Penalise additional answers to zero 3
- (e) $\text{Pt} | \text{Fe}^{2+}(\text{aq}), \text{Fe}^{3+}(\text{aq}) || \text{Ce}^{4+}(\text{aq}), \text{Ce}^{3+}(\text{aq}) | \text{Pt}$
 Correct species (1)
 Correct order (1)
 Deduct one mark for each error 2
- [12]
3. (a) $\text{Pt} | \text{H}_2 | \text{H}^+ || \text{Fe}^{2+} | \text{Fe}$
 Allow 1 for correct order of symbols but lose second mark for a wrong phase boundary(s) / Pt missing / extra Pt on RHS, additional phase boundary
 Note, allow one mark only for correct symbol in reverse:
 $\text{Fe} | \text{Fe}^{2+} || \text{H}^+ | \text{H}_2 | \text{Pt}$
 Allow dashed lines for salt bridge
 Ignore state symbols
 Ignore 2 if used before H^+ 2
- (b) Electron donor
 Allow (species that) loses electrons
 Do not allow reference to electron pairs 1
- (c) Cl_2 / chlorine
 If M1 blank or incorrect cannot score M2 1
- (Species on RHS / electron donor) has most positive / largest E^\ominus / has highest potential
 Do not allow reference to e.m.f. or $E(\text{cell})$ 1
- (d) (i) Cl / chlorine 1
- (ii) Chlorine +1 to chlorine 0
 CE if chlorine not identified in part (i)
 Allow chlorine +1 to chlorine -1 (in Cl^-)
 Allow oxidation state decreases by one OR two
 Allow oxidation state changes by -1 OR -2 1
- (e) $4\text{HOCl} + 4\text{H}^+ + 4\text{OH}^- \rightarrow 2\text{Cl}_2 + \text{O}_2 + 6\text{H}_2\text{O}$
 OR
 $4\text{HOCl} \rightarrow 2\text{Cl}_2 + \text{O}_2 + 2\text{H}_2\text{O}$
 Allow one mark for any incorrect equation that shows
 $\text{HOCl} \rightarrow \text{Cl}_2 + \text{O}_2$
 Allow multiples
 Ignore state symbols
 Penalise one mark for uncancelled or uncombined species (eg $\text{H}_2\text{O} + \text{H}_2\text{O}$ instead of $2\text{H}_2\text{O}$) 2

(f) (i) e.m.f. = $0.40 - (-1.25) = \underline{1.65}$ (V) / $\underline{+1.65}$ (V)
 Allow -1.65 (V)



(iii) **A** / stainless lid
 If **MI** incorrect or blank $\text{CE}=0$

O₂ (electrode) has a more positive E^\ominus / oxygen (electrode) requires / gains electrons from external circuit
 Or reference to the overall equation and a link to electrons going into A
 Allow oxygen is reduced and reduction occurs at the positive electrode

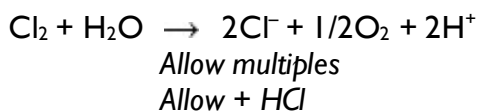
OR Zinc (electrode) has more negative E^\ominus
 Do not allow reference to e.m.f. or $E(\text{cell})$

(iv) (Cell) reaction(s) cannot be reversed / zinc oxide cannot be reduced to zinc by passing a current through it / zinc cannot be regenerated
 Allow danger from production of gas / oxygen produced / hydrogen produced

[14]

4. (a) H_2O_2
 Ignore state symbols

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

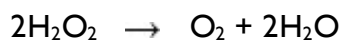
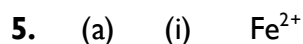


(c) Activation energy is high / light/UV provides the activation energy / light breaks chlorine molecule / Cl-Cl bond
 If light used to break Cl-Cl bond award 1 mark and ignore product e.g. Cl^-

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

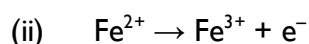
Changes to O(-2) (in water)
 Must give oxidation state of O in water = -2
 $\text{CE} = 0/2$ if refers to oxidation state of H changing

(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**Allow multiples**H⁺ and e⁻ must be cancelled**Use list principle if more than two answers*

(b) (i) e.m.f. = E(rhs) – E(lhs)

$$= 1.52 - 0.77 = 0.75$$

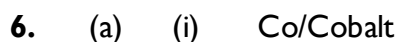
(0.75 scores first mark also)

(iii) Decrease

(Increase is CE, no further marks)

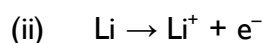
Equilibrium (or reaction) shifts to R
 (or L if refers to half equation in table)
 (or in favour of more Fe³⁺)
 (or more Fe³⁺ formed)
 (or more electrons formed)

Electrode potential (for Fe³⁺/Fe²⁺) less positive (or decreases)

*If Co or Cobalt not given CE = 0**ignore case in symbol for Co*

(+) 4

(+) 3

Allow 4 and 3 in either order*Ignore state symbols**Allow e without -ve sign**Do not allow equilibrium sign*

(iii) Platinum is a conductor

[8]

[10]

(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

(iv) Li reacts with water/forms lithium hydroxide

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

(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

$\text{Pt} | \text{Cl}^-, \text{ClO}_3^- || \text{SO}_4^{2-}, \text{SO}_3^{2-} | \text{Pt}$

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

Oxidising agent ClO_3^-

Reducing agent SO_3^{2-}

[12]

7. (a) By definition

allow ‘set to this value’

(b) 1.23 V

Allow + or –

(c) $\text{Pt} | \text{H}_2(\text{g}) | \text{OH}^-(\text{aq}), \text{H}_2\text{O}(\text{l}) || \text{O}_2(\text{g}) | \text{H}_2\text{O}(\text{l}), \text{OH}^-(\text{aq}) | \text{Pt}$

H_2O not essential, allow reverse order

Correct but with Pt missing

Includes Pt with correct representation

(d) Uses $\text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^- \rightarrow 4\text{OH}^-$

And (2×) $2\text{OH}^- + \text{H}_2 \rightarrow 2\text{H}_2\text{O} + 2\text{e}^-$

$2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$

(e) Increases the surface area (so reaction faster)

(f) Overall reaction is the same ($2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$)

Or shows e.m.f. is the same

(g) Hydrogen and oxygen supplied continuously

OR

Can be operated without stopping to recharge

Or can be refuelled quickly
Allow any one mark

- (h) Hydrogen may need to be made using an energy source that is not 'carbon neutral'

I

I

[10]

8. D

[1]

9. D

[1]