Electrode Potentials & Cells Test Answers

1. (a) (i) 0.60 V

I

(ii) $H_2O + H_2SO_3 \rightarrow SO_4^{2-} + 4H^+ + 2e^-$

I

(b) (i) $2IO_3^- + 2H^+ 5H_2O_2 \rightarrow 5O_2 + I_2 + 6H_2O$ Species

I

Balanced

I

(ii) The concentration of the ions change or are no longer standard or the e.m.f is determined when no current flows

I

(iii) Unchanged

I

(iv) Increased

I

Equilibrium IO_3^-/I_2 displaced to the right

I

Electrons more readily accepted or more reduction occurs or electrode becomes more positive (Q o L)

I

(c) VO_2^+

I

5 or V

I

$V^{2+} + 2H_2O \rightarrow VO_2^+ + 4H^+ 3e^-$

I

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2. (a) (Standard) hydrogen (electrode) **(1)**

I

(b) (i) To allow transfer of electrons / provide a reaction surface **(1)**

(ii) 298 K **(1)**

Both F^{3+} (aq) and Fe^{2+} (aq) have a concentration of 1 mol dm^{-3} **(1)** (QoL)

OR $[H^+]$ = 1 mol dm^{-3}

NOT zero current or 100 kPa

3

(c) +1.34 V **(1)**

$2 MnO_4^- + 5 H_2SO_3 \rightarrow 2 Mn^{2+} + 5 SO_4^{2-} + 3 H_2O + 4 H^+$

Correct species / order **(1)**

Balanced and cancelled **(1)**

Allow one for $2 MnO_4^- + 5 H_2SO_3 \rightarrow 2 Mn^{2+} + 5 SO_4^{2-}$

3

(d) (i) Ce^{4+} (aq) **(1)**

(ii) VO_2^+ (aq) **(1)**; Cl_2 **(1)**

Penalise additional answers to zero

3

(e) Pt | Fe^{2+} (aq), Fe^{3+} (aq) || Ce^{4+}(aq), Ce^{3+} (aq) | Pt

Correct species **(1)**

Correct order **(1)**

Deduct one mark for each error

2

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3. (a) $Pt|H_2|H^+||Fe^{2+}|Fe$

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:
$Fe|Fe^{2+}||H^+|H_2|Pt$

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(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) $4HOCl + 4H^+ + 4OH^- \rightarrow 2Cl_2 + O_2 + 6H_2O$

OR

$4HOCl \rightarrow 2Cl_2 + O_2 + 2H_2O$

Allow one mark for any incorrect equation that shows $HOCl \rightarrow Cl_2 + O_2$
Allow multiples
Ignore state symbols
Penalise one mark for uncancelled or uncombined species (eg $H_2O + H_2O$ instead of $2H_2O$)

2

(f) (i) e.m.f. = 0.40 – (–1.25) = <u>1.65</u> (V) / <u>+1.65</u> (V)
Allow –1.65 (V)

I

(ii) $2Zn + O_2 \rightarrow 2ZnO$
Allow multiples
Ignore state symbols
Do not allow uncancelled species
If more than one equation given, choose the best

I

(iii) **A** / stainless lid
If M1 incorrect or blank CE=0

I

<u>O_2</u> (electrode) has a more positive $E^{\ominus}$ / <u>oxygen</u> (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 <u>Zinc</u> (electrode) has more negative $E^{\ominus}$
Do not allow reference to e.m.f. or E(cell)

I

(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

I

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4. (a) H_2O_2
Ignore state symbols

I

(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

I

$Cl_2 + H_2O \rightarrow 2Cl^- + 1/2O_2 + 2H^+$
Allow multiples
Allow + HCl

I

(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^-

I

(d) <u>O</u> <u>(–1)</u> (in H_2O_2)
Must give oxidation state of O in H_2O_2 = –1

I

Changes to <u>O(–2)</u> (in water)
Must give oxidation state of O in water = –2
CE = 0/2 if refers to oxidation state of H changing

I

(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

I

$2H_2O_2 \rightarrow O_2 + 2H_2O$
Allow multiples
H^+ and e^- must be cancelled

I

[8]

5. (a) (i) Fe^{2+}

I

(ii) F_2O

I

(iii) Fe^{2+}

I

Cl^-

I

Use list principle if more than two answers

(b) (i) e.m.f. = *E*(rhs) – *E*(lhs)

I

= 1.52 – 0.77 = 0.75
(0.75 scores first mark also)

I

(ii) $Fe^{2+} \rightarrow Fe^{3+} + e^-$

I

(iii) Decrease
(Increase is CE, no further marks)

I

Equilibrium (or reaction) shifts to R
(or L if refers to half equation in table)
(or in favour of more Fe^{3+})
(or more Fe^{3+} formed)
(or more electrons formed)

I

Electrode potential (for Fe^{3+}/Fe^{2+}) less positive (or decreases)

I

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6. (a) (i) Co/Cobalt
If Co or Cobalt not given CE = 0
ignore case in symbol for Co

I

(+) 4

I

(+) 3
Allow 4 and 3 in either order

I

(ii) $Li \rightarrow Li^+ + e^-$
Ignore state symbols
Allow e without -ve sign
Do not allow equilibrium sign

I

(iii) Platinum is a conductor

I

(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

I

(iv) Li reacts with water/forms lithium hydroxide

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

I

(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) $ClO_3^- + 3SO_3^{2-} \rightarrow Cl^- + 3SO_4^{2-}$

I

Oxidising agent ClO_3^-

I

Reducing agent SO_3^{2-}

I

[12]

7. (a) By definition

allow 'set to this value'

I

(b) 1.23 V

Allow + or –

I

(c) $Pt|H_2(g)|OH^-(aq),H_2O(l)||O_2(g)|H_2O(l),OH^-(aq)|Pt$

H_2O not essential, allow reverse order

Correct but with Pt missing

I

Includes Pt with correct representation

I

(d) Uses $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$
And (2×) $2OH^- + H_2 \rightarrow 2H_2O + 2e^-$

I

$2H_2 + O_2 \rightarrow 2H_2O$

I

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

I

(f) Overall reaction is the same ($2H_2 + O_2 \rightarrow 2H_2O$)

Or shows e.m.f. is the same

I

(g) Hydrogen and oxygen supplied continuously
OR
Can be operated without stopping to recharge

Or can be refuelled quickly
Allow any one mark

1

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

1

[10]

8. D

[1]

9. D

[1]