

M1.(a) The ions in the ionic substance in the salt bridge move through the salt bridge 1

To maintain charge balance / complete the circuit 1

(b) F^- 1

(c) $E^\ominus SO_4^{2-} / SO_2$ $E^\ominus Br_2 / Br^-$
Allow correct answer expressed in words, eg electrode potential for sulfate ions / sulfur dioxide is less than that for bromine / bromide 1

(d) 1.23 (V) 1

(e) A fuel cell converts more of the available energy from combustion of hydrogen into kinetic energy of the car / an internal combustion engine wastes more (heat) energy 1

[6]

M2.(a) To remove the oxide layer on the aluminium
*Do not allow 'cleaning' or 'removal of grease'.
Do not allow 'removal of impurities' without qualification.* 1

(b) An appropriate method for delivering H_2 gas over a Pt electrode
Need H_2 gas and Pt electrode labelled (allow gas delivered directly below the electrode). 1

The Pt electrode must clearly be in contact with a solution of a named acid.

Ignore any concentration or pressure values.

Ignore absence of bubbles.

Allow if electrode is below outer acid level.

1

- (c) The carbonate ion reacts with the acid (in the SHE) / reaction between carbonate and Al^{3+}

Lose this mark if aluminium carbonate formed but mark on.

1

Reaction given (either equation or products specified)

OR H^+ / Al^{3+} concentrations change / cell e.m.f. altered

1

[5]

M3.(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)

1

(ii) $2\text{Zn} + \text{O}_2 \rightarrow 2\text{ZnO}$

Allow multiples

Ignore state symbols

Do not allow uncancelled species

If more than one equation given, choose the best

1

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

1

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(cell)

1

- (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

1

[14]

M4.(a) It has mobile ions / ions can move through it / free ions

Do not allow movement of electrons.

Allow specific ions provided they are moving but do not react.

1

- (b) Chloride ions react with copper ions / Cu²⁺ **OR** [CuCl₄]²⁻ formed
If incorrect chemistry, mark = 0

1

- (c) The Cu²⁺ ions / CuSO₄ in the left-hand electrode more concentrated
Allow converse.

1

So the reaction of Cu^{2+} with 2e^- will occur (in preference at) left-hand electrode / $\text{Cu} \rightarrow \text{Cu}^{2+} + \text{electrons}$ at right-hand electrode

Allow left-hand electrode positive / right-hand electrode negative.

Also reduction at left-hand electrode / oxidation at right-hand electrode.

Also left-hand electrode has oxidising agent / right-hand electrode has reducing agent.

Allow E left-hand side $>$ E right-hand side

1

- (d) (Eventually) the copper ions / CuSO_4 in each electrode will be at the same concentration

1

- (e) (i) -3.05 (V)
Must have minus sign.
 -3.05 only.

1

- (ii) $\text{LiMnO}_2 \rightarrow \text{Li} + \text{MnO}_2$ correct equation
Allow 1 for reverse equation.
Allow multiples.

1

Correct direction

If Li^+ not cancelled but otherwise correct, max = 1

If electrons not cancelled, CE = 0

$\text{LiMnO}_2 \rightarrow \text{Li} + \text{MnO}_2$ scores 2

$\text{Li}^+ + \text{LiMnO}_2 \rightarrow \text{Li}^+ + \text{Li} + \text{MnO}_2$ scores 1

$\text{Li} + \text{MnO}_2 \rightarrow \text{LiMnO}_2$ scores 1

1

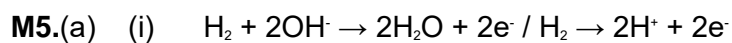
- (iii) Electricity for recharging the cell may come from power stations burning (fossil) fuel

Allow any reference to burning (of carbon-containing) fuels.

Note combustion = burning.

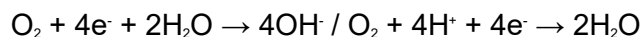
1

[9]



Any order

1



1

(ii) Hydrogen (electrode) produces electrons

Ignore reference to salt bridge

Do not allow at negative / positive electrode – must identify hydrogen and oxygen

1

Oxygen (electrode) accepts electrons

Allow electrons flow to the oxygen electrode

1

(b) Hydrogen / the fuel / reactants supplied continuously / fed in

Do not accept oxygen supplied as the only statement

1

(c) In the fuel cell, a greater proportion of the energy available from the hydrogen–oxygen reaction is converted into useful energy

Allow less energy wasted / more efficient

Do not allow reference to safety

1

(d) Hydrogen is flammable / H^+ corrosive / OH^- corrosive / hydrogen explosive

1

[7]

M6.(a) Solar cells do not supply electrical energy all the time

1

Rechargeable cells can store electrical energy for use when the solar cells are not working

1

- (b) Prevent pollution of the environment by toxic or dangerous substances / recycling of valuable components

Do not allow 'will not use up landfill sites'.

1

[3]