



A-Level Chemistry

Electrochemical Cells

Mark Scheme

Time available: 60 minutes
Marks available: 58 marks

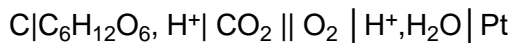
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Mark schemes

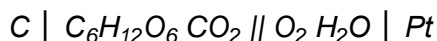
1. (a) Lithium would react with the electrolyte/water
Allow water will oxidise Li to Li⁺ or Li will reduce water to hydrogen 1
- E^\ominus for Li⁺(/Li) more negative than for water or EMF= 2.21(V)
 or E^\ominus Li⁺ (/Li) < H₂O(/H₂, OH⁻)
Ignore EMF is negative 1
- (b) $0.54 - (-3.04) = \underline{3.58}$ (V) 1
- (c) Non-standard conditions
Allow non-aqueous conditions or different conditions 1
- (d) (+) 7
Accept VII 1
- (e) Li⁺ + CoO₂ + e⁻ → Li⁺CoO₂⁻ or
 Li⁺ + CoO₂ + e⁻ → LiCoO₂ 1
- (f) Li → Li⁺ + e⁻ 1
- [7]
2. (a) C₆H₁₂O₆ + 6 H₂O → 6 CO₂ + 24 H⁺ + 24 e⁻
Accept multiples 1
- (b) O₂ + 4 H⁺ + 4 e⁻ → 2 H₂O
Accept multiples 1
- (c) C₆H₁₂O₆ + 6 O₂ → 6 CO₂ + 6 H₂O
Accept multiples 1



OR



M1 Must see following in correct order:



M2 Cell completely correct

Ignore H_2O on LHS

Ignore state symbols

Allow $H^+(aq) | H_2O(l)$ on RHS

0 marks if electrons included.

2

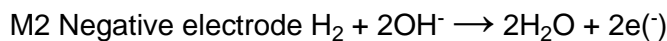
- (e) (Constantly) add reactants/glucose (and oxygen) OR keep concentration of reactants constant

1

[6]

3.

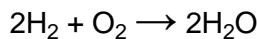
- (a) (i) M1 Positive electrode $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$



Allow multiples, ignore state symbols

If equations both correct but at the wrong electrodes allow 1 mark

1
1



Mark independently

Must be this way round

1

- (ii) Increase (emf)

If decrease/no change then $CE=0/2$; if blank then mark on

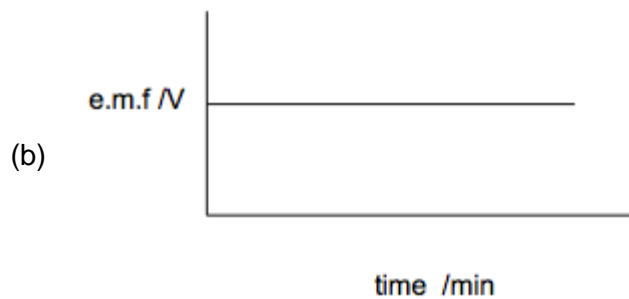
1



Or overall equation moves to the right

Allow $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$ will move to the right / oxygen half equation moves to the RHS / $E^\ominus O_2|OH^-$ half cell moves to the right

1



Must start at y-axis

1

(c) (i) Unchanged

1

(ii) Water is the only product / fuel cell does not give out pollutants such as NO_x or CO₂ or SO₂ or C or CO or C_xH_y or unburnt hydrocarbons

Not fuel cell does not give out pollutants unless pollutant stated

1

(d) CO₂ is released because fossil fuels are burned to produce electricity to generate hydrogen
OR

CO₂ is released when methane reacts with steam to produce hydrogen

Allow CO₂ is released to produce the hydrogen

1

[9]

4.

(a) (i) $H_2 + 2OH^- \rightarrow 2H_2O + 2e^-$ / $H_2 \rightarrow 2H^+ + 2e^-$

Any order

1

$O_2 + 4e^- + 2H_2O \rightarrow 4OH^-$ / $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$

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]

5.

- (a) Electron acceptor / gains electrons / takes electrons away

Do not allow electron pair acceptor / gain of electrons / definition of redox (QWC)

1

- (b) Cd(OH)₂

Do not allow 'Cd(OH)₂/Cd'

1

Species (on LHS) with the least positive/most negative electrode potential / lowest E / smallest E

Only allow this mark if M1 answer given correctly or blank

Do not allow negative emf

1

- (c) (i) 1.5 (V) / 1.50

1

- (ii) $2\text{MnO}_2 + 2\text{H}_2\text{O} + \text{Zn} \rightarrow 2\text{MnO}(\text{OH}) + 2\text{OH}^- + \text{Zn}^{2+}$

Ignore state symbols

e⁻ must be cancelled

(take care that Zn²⁺ is on RHS)

1

- (iii) Allows ions to pass (through it) or words to that effect

Penalise passage of electrons

Allow mention of particular ions

1

- (iv) Allows electrons to flow / makes electrical contact / conductor

Allow acts as an (inert) electrode / anode / cathode

1

- (v) Zn is 'used up' / has reacted / oxidised

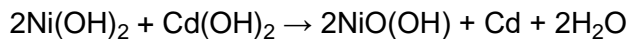
Allow idea that zinc reacts

Do not allow just zinc corrodes

1

- (d) (i) 3 / +3 / III

1



For correct nickel and cadmium species in correct order (allow H₂O missing and OH⁻ not cancelled)

1

For balanced equation (also scores M2)

Allow max 1 for M2 and M3 if correct balanced equation but reversed.

Ignore state symbols

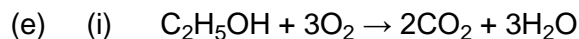
1

- (ii) Metal / metal compounds are re-used / supplies are not depleted / It (the cell) can be re-used

Allow does not leak / no landfill problems / less mining / less energy to extract metals / less waste

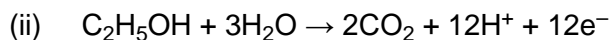
Do not allow less CO₂ unless explained

1



Allow C₂H₆O

1



Allow C₂H₆O

1

(iii) (+)0.23 (V)

1

- (iv) CO₂ released by combustion / fermentation / fuel cell / reaction with water

Can be answered with the aid of equations

1

(atmospheric) CO₂ taken up in photosynthesis

1

[17]

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]