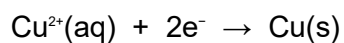


If equations reversed, allow M1 only.

1



Ignore state symbols.

1

(b) Moles of copper(II) reacted = $(100 / 1000) \times 0.5 = 0.05$

1

Moles of zinc reacted = 0.05

1

Mass of zinc lost = $0.05 \times 65.4 = 3.27 \text{ g}$

Correct final answer without working scores M3 only.

1

(c) Allow cell to discharge until $[\text{Cu}^{2+}]$ is 0.5

Alternative: Allow cell to discharge completely.

1

Confirmed by colorimetric measurement or other suitable method

Solution colourless or use of chemical test to determine absence of copper(II)

1

Weigh the Zn electrode before and after the experiment

Weigh Zn electrodes before and after and halve the mass change.

1

[8]

M2.(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 Cu²⁺ with 2e⁻ will occur (in preference at) left-hand electrode
/ Cu → Cu²⁺ + 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 / CuSO₄ in each electrode will be at the same concentration

1

(e) (i) -3.05 (V)

Must have minus sign.

-3.05 only.

1

(ii) LiMnO₂ → Li + MnO₂ 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]

- M3.(a)** Electron acceptor / gains electrons / takes electrons away

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

1

- (b) $\text{Cd}(\text{OH})_2$

Do not allow ' $\text{Cd}(\text{OH})_2/\text{Cd}$ '

1

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

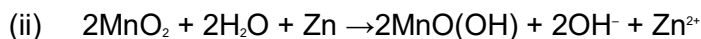
Only allow this mark if M1 answer given correctly or blank

Do not allow negative emf

1

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

1



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

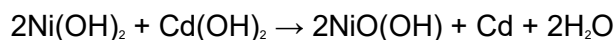
Allow idea that zinc reacts

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

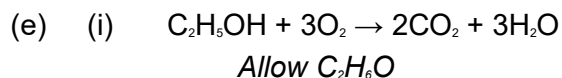
1

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

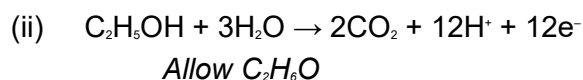
Allow does not leak / no landfill problems / less mining / less energy to extract metals / less waste

Do not allow less CO₂ unless explained

1



1



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]

M4.(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 H₂ gas over a Pt electrode

Need H₂ 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]

- M5.(a)** Diagram of an Fe^{3+} / Fe^{2+} electrode that includes the following parts labelled:
Solution containing Fe^{2+} and Fe^{3+} ions

1

Platinum electrode connected to one terminal of a voltmeter

Must be in the solution of iron ions (one type will suffice)

1

Salt bridge

Do not allow incorrect material for salt bridge and salt bridge must be in the solution (ie it must be shown crossing a meniscus)

1

298 K and 100 kPa / 1 bar

1

all solutions unit / 1 mol dm^{-3} concentration

Allow zero current / high resistance voltmeter as alternative

to M4 or M5

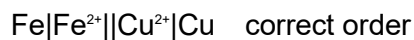
Ignore hydrogen electrode even if incorrect

1



Ignore state symbols

1



Allow $\text{Cu}|\text{Cu}^{2+}||\text{Fe}^{2+}|\text{Fe}$

1

Phase boundaries and salt bridge correct, no Pt

Allow single / double dashed line for salt bridge

Penalise phase boundary at either electrode end

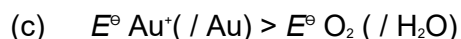
Can only score M3 if M2 correct

1

Copper electrode

Allow any reference to copper

1



Allow $E_{\text{cell}} / \text{e.m.f.} = 0.45 \text{ V}$

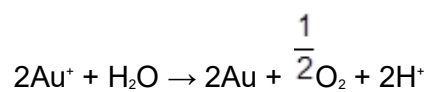
Allow $1.68 > 1.23$

1

So Au^+ ions will oxidise water / water reduces Au^+

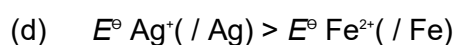
QoL

1



Allow multiples

1



Allow E cell / e.m.f. = 1.24

Allow 0.80 > -0.44

1

And $E^\ominus \text{Ag}^+ / \text{Ag} > E^\ominus \text{Fe}^{3+} / \text{Fe}^{2+}$

Allow E cell / e.m.f. = 0.03

Allow 0.80 > 0.77

1

So silver ions will oxidise iron (to iron(II) ions) and then oxidise Fe(II) ions (further to Fe(III) ions producing silver metal)

Allow Ag⁺ ions will oxidise iron to iron(III)

1

[15]