

M1.(a) Diagram of an $\text{Fe}^{3+} / \text{Fe}^{2+}$ 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

(b) $\text{Cu}^{2+} + \text{Fe} \rightarrow \text{Cu} + \text{Fe}^{2+}$

Ignore state symbols

1

$\text{Fe}|\text{Fe}^{2+}||\text{Cu}^{2+}|\text{Cu}$ correct order

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

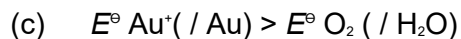
Can only score M3 if M2 correct

1

Copper electrode

Allow any reference to copper

1



Allow E cell / e.m.f. = 0.45 V

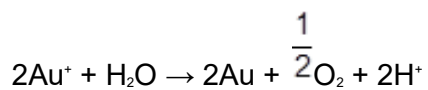
Allow 1.68 > 1.23

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

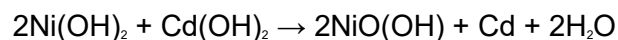
Allow Ag⁺ ions will oxidise iron to iron(III)

1

[15]

- M2.(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) $2\text{MnO}_2 + 2\text{H}_2\text{O} + \text{Zn} \rightarrow 2\text{MnO(OH)} + 2\text{OH}^- + \text{Zn}^{2+}$
Ignore state symbols
 e^- must be cancelled
(take care that Zn^{2+} 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

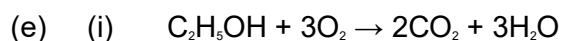
1

(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

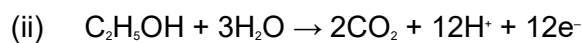
Do not allow less CO₂ unless explained

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) CO_2 taken up in photosynthesis

1

[17]

M3.(a) loses electrons / donates electrons

penalise donates electron pair

1

(b) Zn

1

(most) negative E° / lowest E° / least positive

can only score M2 if M1 correct

do not allow e.m.f instead of E°

1

(c) $E^\circ \text{F}_2 (\text{F}^-) > E^\circ \text{O}_2 (\text{H}_2\text{O})$

or e.m.f is positive or e.m.f = 1.64 V

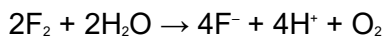
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Fluorine reacts to form oxygen (can score from equation in M3 even if equation unbalanced provided no contradiction)

or fluorine oxidises water

or fluorine is a more powerful oxidising agent than oxygen

1



allow 4HF in equation

balanced equation scores M2 and M3

1

(d) (i) order correct Zn Zn^{2+} Ag_2O Ag or reverse of this order

ignore ss, H^+ and H_2O , no. of moles

1

all phase boundaries correct

allow $\text{Zn}|\text{Zn}^{2+}||\text{Ag}_2\text{O},\text{Ag}$

or $\text{Zn}|\text{Zn}^{2+}||\text{Ag}_2\text{O}|\text{H}^+|\text{Ag}$ for M1 & M2

e.g. $\text{Zn}|\text{Zn}^{2+}||\text{Ag}_2\text{O}|\text{Ag}$ or $\text{Ag}|\text{Ag}_2\text{O}||\text{Zn}^{2+}|\text{Zn}$ scores 2

M2 cannot be gained unless M1 scored

allow H^+ either side of Ag_2O with comma or |
for M2 penalise

- wrong phase boundary (allow dashed lines for salt bridge)
- Pt
- use of + (from half equation)
- water/ H^+ outside Ag in Ag electrode

1

(ii) 1.1 (V)

Allow no units, penalise wrong units
allow correct answer even if no answer to (d)(i) or answer to (d)(i) incorrect
allow -1.1 if silver electrode on Left in (d)(i) even if the species are in the wrong order.

1

(iii) Reaction(s) not reversible or H_2O electrolyses

do not allow hard to reverse
mention of primary cell is not enough to show that reaction(s) are irreversible

1

(e) (i) -0.46 (V)

Allow no units, penalise wrong units

1

(ii) $2PbSO_4 + 2H_2O \rightarrow Pb + PbO_2 + 2HSO_4^- + 2H^+$

lead species correct on correct sides of equation

1

equation balanced and includes H_2O ,

HSO_4^- and H^+ (or H_2SO_4)

allow ions / species must be fully cancelled out or combined
allow 1/2 for balanced reverse equation

1

(f) (i) reagents / PbO_2 / H_2SO_4 / acid / ions used up
(or concentration decreases)

1

(ii) fuel cell

Ignore any other words

1

(iii) reagents / fuel supplied continuously

1

concentrations (of reagents) remain constant

1

[17]

M4. (a) 1.4 V

Allow + or –

1

(b) $2\text{NiO}(\text{OH}) + 2\text{H}_2\text{O} + \text{Cd} \rightarrow 2\text{Ni}(\text{OH})_2 + \text{Cd}(\text{OH})_2$

Mark for species, Deduct a mark for additional species (eg OH) but allow balance mark

1

Balanced

If equation is reversed CE=0

1

(c) NiO(OH) or Ni(III) or nickel

1

+3

Allow conseq on wrong species

1

[5]