1. (a) Electron acceptor / gains electrons

do not allow electron pair acceptor

1

(b) Fe^{2+} ions

1

Fe^{2+} / Fe or Fe^{2+} or it has smallest / most negative electrode potential / E°

Do not allow Fe / Fe^{2+}

Cannot score M2 if M1 incorrect

1

(c) $Pt|H_2|H^+||Ag^+|Ag$

M1 for H_2 H^+ Ag^+ Ag in correct order

1

allow dashed phase boundaries

$2H^+$ loses one mark (M2)

M2 for Pt correct and correct phase boundaries

Ignore state symbols. M1 must be correct to score M2

If answer correct but all in reverse order allow 1 mark out of two

1

Any **two** correct conditions

- 298 K / 25 °C
- 100 kPa
- both solutions of unit concentration
- zero current

Allow 1 bar; Do not apply list principle, mark correct answers.

2

(d) E Au^+(/ Au) > E O_2 (/ H_2O) OR e.m.f. / *E*cell = 0.45 V

If both species in electrode given, must be in correct order i.e. Au+ / Au

1

Au^+ (ions) oxidise water OR water reduces Au^+ (ions)

Allow water donates electrons to Au+

1

Gold metal / solid / precipitate **OR** bubbles / effervescence of (oxygen gas) / gas produced

Penalise incorrect observations

1

$2Au^+ + H_2O \rightarrow 2Au + 2H^+ + \frac{1}{2} O_2$ OR $4Au^+ + 2H_2O \rightarrow 4Au + 4H^+ + O_2$

Allow multiples

1

(e) (i) 1.24 (V)

Do not allow 1.24

1

(ii) Chloride ions / Cl react with / form a precipitate with silver ions / Ag+ / form AgCl

Penalise reaction of chloride ions with iron ions or iron

1

(f) E O_2 (/ H_2O) > E Fe^{3+} (/ Fe^{2+}) (or e.m.f / *E*cell = 0.46 V)

Species in electrode if all given must be in correct order

1

Therefore the iron(II) ions are oxidised (or converted) into iron(III) ions (by oxygen)

If chloride ions oxidised to chlorine, lose M2
M2 can be obtained or lost from equation.
Ignore observations.

1

[15]

2. (a) *Hydrogen ion concentration*: 1.00 mol dm^{-3} **(1)**
Hydrogen gas pressure: 100 kPa **(1)**

2

(b) *Explanation of change*: Equilibrium displaced to left **(1)**
to reduce constraint **(1)**
Change in electrode potential: Becomes negative or decreases **(1)**
allow more negative

3

(c) (i) 0.43V **(1)**

(ii) *Half-equation*: $2Br^- \rightarrow Br_2 + 2e^-$ **(1)**
Overall equation: $2BrO_3^- + 10Br^- + 12H^+ \rightarrow 6Br_2 + 6H_2O$ **(2)**
or $BrO_3^- + 5Br^- + 6H^+ \rightarrow 3Br_2 + 3H_2O$
species ***(1)***
balanced ***(1)***

4

[9]

3. (a) 1.4 V →
Allow + or –

1

(b) $2NiO(OH) + 2H_2O + Cd \rightarrow 2Ni(OH)_2 + Cd(OH)_2$
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]

4. (a) loses electrons / donates electrons
penalise donates electron pair

1

(b) Zn

1

(most) negative E^{o} / lowest E^{o} / least positive
can only score M2 if M1 correct
do not allow e.m.f instead of E^{o}

1

(c) $\underline{E^{o}\ F_2}$ ($/F^-$) > $\underline{E^{o}\ O_2}$ ($/H_2O$)
or e.m.f is positive or e.m.f = 1.64 V

1

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

$2F_2 + 2H_2O \quad 4F^- + 4H^+ + O_2$
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 $Zn|Zn^{2+}||Ag_2O,Ag$
or $Zn|Zn^{2+}||Ag_2O|H^+|Ag$ for M1 & M2
e.g. $Zn|Zn^{2+}||Ag_2O|Ag$ or $Ag|Ag_2O||Zn^{2+}|Zn$ 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) $2PbSO_4 + 2H_2O$ $Pb + PbO_2 + 2HSO_4^- + 2H^+$
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]

5. B **[1]**

6. C **[1]**

7. C **[1]**

8. D **[1]**