M1.(a) (i) **M1** (+) 4 **OR** IV

M2 (+) 6 **OR** VI

2

(ii) It / Chlorine has gained / accepted electron(s)

OR

Correctly balanced half-equation eg $Cl_2 + \mathbf{2}e^- \longrightarrow \mathbf{2}Cl^-$

Credit 1 or 2 electrons but not lone pair.

The idea of 'reduction' alone is not enough.

1

(b) (i) $\mathbf{6}KI + \mathbf{7}H_2SO_4 \longrightarrow \mathbf{6}KHSO_4 + \mathbf{3}I_2 + S + \mathbf{4}H_2O$

1

(ii) $\mathbf{2}I^- \longrightarrow I_2 + \mathbf{2}e^-$

OR

$8I^- \longrightarrow 4I_2 + 8e^-$

Ignore charge on the electron unless incorrect.

Or multiples.

Credit the electrons being subtracted on the LHS.

Ignore state symbols.

1

(iii) $H_2SO_4 + \mathbf{8}H^+ + \mathbf{8}e^- \longrightarrow H_2S + \mathbf{4}H_2O$

OR

$SO_4^{2-} + \mathbf{10}H^+ + \mathbf{8}e^- \longrightarrow H_2S + \mathbf{4}H_2O$

Ignore charge on the electron unless incorrect.

Or multiples.

Credit the electrons being subtracted on the RHS.

Ignore state symbols.

1

(c) (i) Ag^{+} + I^{-} $\longrightarrow$ AgI ONLY

Ignore state symbols.

Not multiples.

1

(ii) The precipitate / solid / it does not dissolve / is insoluble / remains

OR a white / cream / yellow solid / precipitate

OR stays the same

OR no (visible / observable) change

OR no effect / no reaction

Ignore 'nothing (happens)'.

Ignore 'no observation'.

1

(iii) The silver nitrate is acidified to

- react with / remove (an)ions that would interfere with the test

  Credit a correct reference to ions that give a 'false positive'.

- prevent the formation of other silver precipitates / insoluble silver compounds that would interfere with the test

  Do not penalise an incorrect formula for an ion that is written in addition to the name.

- remove (other) ions that react with the silver nitrate

  If only the formula of the ion is given, it must be correct.

- react with / remove carbonate / hydroxide / sulfite (ions)

  Ignore 'sulfate'.

1

(iv) HCl would form a (white) precipitate / (white) solid (with silver nitrate and this would interfere with the test)

*It is not sufficient simply to state either that it will interfere **or** simply that the ions / compounds react to form AgCl*

1

(d) (i) Any **one** from

Ignore 'to clean water'.

- to sterilise / disinfect water

Ignore 'water purification' and 'germs'.

- to destroy / kill microorganisms / bacteria / microbes / pathogens

Credit 'remove bacteria etc' / prevent algae.

1

(ii) The (health) benefit outweighs the risk

OR

a clear statement that once it has done its job, little of it remains

OR

used in (very) dilute concentrations / small amounts / low doses

1

(iii) $Cl_2 + H_2O \longrightarrow HClO + HCl$

OR

$Cl_2 + H_2O \longrightarrow \mathbf{2}H^+ + ClO^- + Cl^-$

OR

$\mathbf{2}Cl_2 + \mathbf{2}H_2O \longrightarrow \mathbf{4}HCl + O_2$

Credit HOCl or ClOH
Or multiples.
Credit other ionic or mixed representations.
Ignore state symbols.

1

(e) **In either order - Both required for one mark only**

Credit correct ionic formulae.

NaClO (OR NaOCl) **and** NaCl

Give credit for answers in equations unless contradicted.

1

[14]

M2.(a) $Pt|H_2|H^+||Fe^{2+}|Fe$

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:

$Fe|Fe^{2+}||H^{+}|H_2|Pt$

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(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) $4HOCl + 4H^{+} + 4OH^{-} \rightarrow 2Cl_2 + O_2 + 6H_2O$

OR

$4HOCl \rightarrow 2Cl_2 + O_2 + 2H_2O$

Allow one mark for any incorrect equation that shows

$HOCl \rightarrow Cl_2 + O_2$

Allow multiples

Ignore state symbols

Penalise one mark for uncancelled or uncombined species (eg $H_2O + H_2O$ instead of $2H_2O$)

2

(f) (i) e.m.f. = 0.40 – (–1.25) = <u>1.65</u> (V) / <u>+1.65</u> (V)

Allow –1.65 (V)

1

(ii) $2Zn + O_2 \rightarrow 2ZnO$

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

<u>O_2</u> (electrode) has a more positive $E^\ominus$ / <u>oxygen</u> (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 <u>Zinc</u> (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]

M3.(a) (i) $SiO_2 + \mathbf{2}Cl_2 + \mathbf{2}C \longrightarrow SiCl_4 + \mathbf{2}CO$

Ignore state symbols

Credit multiples of either equation

OR

$SiO_2 + \mathbf{2}Cl_2 + C \longrightarrow SiCl_4 + CO_2$

1

(ii) (fractional) distillation

OR

G(L)C or gas (–liquid–) chromatography

1

(b) (i) $SiCl_4 + \mathbf{2}H_2 \longrightarrow Si + \mathbf{4}HCl$

Ignore state symbols

Credit multiples

Penalise ionic HCl

1

(ii) Reducing agent / reductant / reduces $SiCl_4$ / reduces (silicon) / electron donor

1

(iii) Explosion / explosive

OR

(highly) flammable / inflammable

OR

<u>readily</u> / <u>easily</u> ignites / burns / combusts

1

(c)

$\mathbf{2}MgO + Si \longrightarrow \mathbf{2}Mg + SiO_2$

Ignore state symbols

Credit multiples

1

[6]

M4.(a) (i) $3CuS(s) + \mathbf{8}HNO_3(aq) \longrightarrow \mathbf{3}CuSO_4(aq) + \mathbf{8}NO(g) + \mathbf{4}H_2O(l)$

1

(ii) **(+) 5**

(+) 2

2

(iii) $\mathbf{4}H^+ + NO_3^- + \mathbf{3}e^- \longrightarrow \mathbf{2}H_2O + NO$

Ignore state symbols.

*Credit multiples of **this equation only**.*

Ignore absence of charge on the electron.

1

(iv) $S^{2-} + \mathbf{4}H_2O \longrightarrow SO_4^{2-} + \mathbf{8}e^- + \mathbf{8}H^+$

Ignore state symbols.

*Credit multiples of **this equation only**.*

Ignore absence of charge on the electron.

1

(b) M1 add <u>scrap / recycled / waste iron (or steel)</u> to the aqueous solution

*If **M1** refers to iron / steel, but does not make it clear in the text that it is "scrap" / "waste" / "recycled", penalise **M1** but mark on.*

M2 the iron is a <u>more reactive</u> metal ***OR*** <u>Fe is a better reducing agent</u>

*Credit zinc or magnesium as an alternative to iron for **M2**, **M3** and **M4** only, penalising **M1***

M3 <u>Cu^{2+} / copper ions</u> are <u>reduced</u> / <u>gain electrons</u>

OR $Cu^{2+} + 2e^- \longrightarrow Cu$

OR <u>copper / Cu is displaced by Fe</u>

Ignore absence of charge on the electron.

M4 $Fe + Cu^{2+} \longrightarrow Fe^{2+} + Cu$ ONLY

*For **M4**, ignore state symbols*

4

[9]

M5. (a) Ti is not produced

OR

TiC / <u>carbide</u> is produced OR titanium reacts with carbon

OR

Product is brittle

OR

Product is a poor engineering material

Penalise "titanium carbonate"

Ignore "impure titanium"

Credit "it / titanium is brittle"

1

(b) (i) $FeTiO_3 + \mathbf{3\tfrac{1}{2}}Cl_2 + \mathbf{3}C \longrightarrow FeCl_3 + TiCl_4 + \mathbf{3}CO$

Ignore state symbols

Credit multiples

1

(ii) $FeCl_3 + TiCl_4 + \mathbf{7}Na \longrightarrow \mathbf{7}NaCl + Fe + Ti$

OR (for example)

$2FeCl_3 + TiCl_4 + \mathbf{10}Na \longrightarrow \mathbf{10}NaCl + 2Fe + Ti$

Ignore state symbols

Credit multiples including ratios other than 1:1

Ignore working

1

(c) Either order

*Penalise reference to incorrect number of electrons in **M1***

M1 The Cu^{2+} / copper(II) ions / they have gained (two) electrons

OR $Cu^{2+} + 2e^{-} \longrightarrow Cu$

*For **M1**, accept "copper" if supported by correct half-equation or simplest ionic equation*

OR oxidation state / number decreases (or specified from 2 to 0)

Ignore charge on the electron

M2 The <u>Cu^{2+} / copper(II) ions / they</u> have been <u>reduced</u>

*For **M2** do **not** accept "copper" alone*

2

(d) $2O^{2-} \longrightarrow O_2 + \mathbf{4}e^{-}$

Or multiples including

$\mathbf{3}O^{2-} \longrightarrow \mathbf{1.5}\ O_2 + \mathbf{6}e^{-}$

Ignore state symbols

Ignore charge on the electron

Credit the electrons being subtracted on the LHS

1

[6]

M6. (a) $\mathbf{2}Ca_5F(PO_4)_3 + 9SiO_2 + \mathbf{15}C \longrightarrow 9CaSiO_3 + CaF_2 + \mathbf{15}CO + \mathbf{6}P$

1

(b) **M1** (P_4 =) **0**

M2 (H_3PO_4 =) **(+) 5**

*Accept Roman numeral V for **M2***

2

(c) H_2SO_4

***Both numbers** required*

M_r = 2(1.00794) + 32.06550 + 4(15.99491)
= **98.06102 or 98.0610 or 98.061 or 98.06 or 98.1**

Calculations not required

<u>**and**</u>

H_3PO_4

M_r = 3(1.00794) + 30.97376 + 4(15.99491)
= **97.97722 or 97.9772 or 97.977 or 97.98 or 98.0**

1

(d) (i) A substance that speeds up a reaction OR alters / increases the rate of a reaction **AND** is chemically unchanged at the end / not used up.

Both ideas *needed*

Ignore reference to activation energy or alternative route.

1

(ii) The addition of water (**QoL**) to a molecule / compound

QoL- for the underlined words

1

(iii) **M1** $CH_3CH{=}CH_2 + H_2O \longrightarrow CH_3CH(OH)CH_3$

(C_3H_6)

For ***M1*** *insist on correct structure for the alcohol but credit correct equations using either* C_3H_6 *or double bond not given.*

M2 propan-2-ol

2

[8]