1

(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]

2 (a) Ti is not produced

OR

TiC / carbide 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) $FeTiO_3 + \mathbf{3}½Cl_2 + \mathbf{3}C \longrightarrow FeCl_3 + TiCl_4 + \mathbf{3}CO$

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 Cu^{2+} / copper(II) ions / they have been reduced

*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]

3

(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]

4

(a) (i) **M1** **0**

M2 **(+) 5**

Accept Roman V for M2

2

(ii) $I_2 + 10HNO_3 \longrightarrow \mathbf{2}HIO_3 + \mathbf{10}NO_2 + \mathbf{4}H_2O$

Accept multiples

1

(b) **M1** $IO_3^- + \mathbf{6}H^+ + \mathbf{5}I^- \longrightarrow \mathbf{3}I_2 + \mathbf{3}H_2O$

For M1, ignore state symbols

Credit multiples

Accept $2\frac{1}{2}I_2 + \frac{1}{2}I_2$ as alternative to $3I_2$

Electrons must be cancelled

M2 $NaIO_3$ ***OR*** IO_3^- ***OR*** iodate ions ***OR*** iodate(V) ions etc.

For M2 Do not penalise an incorrect name for the correct oxidising agent that is written in addition to the formula.

Accept "the iodine in iodate ions" but NOT "iodine" alone

Accept "the iodine / I in iodate ions" but NOT "iodine" alone

2

(c) (i) Iodine ***OR*** I_2

Insist on correct name or formula

1

(ii) $H_2SO_4 + \mathbf{6}H^+ + \mathbf{6}e^- \longrightarrow S + \mathbf{4}H_2O$

Ignore state symbols

$SO_4^{2-} + \mathbf{8}H+ + \mathbf{6}e^- \longrightarrow S + \mathbf{4}H_2O$

Credit multiples

Do not penalise absence of charge on the electron

1

(d) hydrogen sulfide

OR H_2S

OR hydrogen sulphide

1

(e) (i) $Ag^+ + I^- \longrightarrow AgI$ ONLY

Ignore state symbols

No multiples

1

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

ignore "nothing (happens)"

OR turns to a <u>white solid</u>

ignore "no observation"

OR stays the same

OR no (visible/ observable) change

OR no effect / no reaction

1

(iii) The silver nitrate is acidified to

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

  Ignore reference to "false positive"

- prevent the formation of other <u>silver precipitates / insoluble silver compounds</u> 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) <u>ions that react with the silver nitrate</u>

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

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

1

(f) (i) An <u>electron donor</u>

Penalise "electron pair donor"

OR (readily) <u>donates / loses / releases / gives (away) electron(s)</u>

Penalise "loss of electrons" alone

Accept "electron donator"

1

(ii) $Cl_2 + 2e^- \longrightarrow 2Cl^-$

Ignore state symbols

Do not penalise absence of charge on electron

Credit $Cl_2 \longrightarrow 2Cl^- - 2e^-$

Credit multiples

1

(iii) For M1 and M2, iodide ions are stronger reducing agents than chloride ions, because

Ignore general statements about Group VII trends or about halogen molecules or atoms. Answers must be specific

M1 Relative size of ions

CE=0 for the clip if "iodine ions / chlorine ions" ***QoL***

Iodide ions / they are larger /have more electron levels(shells) (than chloride ions) / larger atomic / ionic radius

CE=0 for the clip if "iodide ions are bigger molecules / atoms" ***QoL***

OR electron to be lost/outer shell/level (of the iodide ion) is further the nucleus

OR iodide ion(s) / they have greater / more shielding

Insist on iodide ions in M1 and M2 or the use of it / they / them, in the correct context (or chloride ions in the converse argument)

OR converse for chloride ion

M2 Strength of attraction for electron(s)

Must be comparative in both M1 and M2

The electron(s) lost /outer shell/level electron from (an) iodide ion(s) less strongly held by the nucleus compared with that lost from a chloride ion

OR converse for a chloride ion

2

[15]

5 (a) (i) $2MoS_2 + 7O_2 \longrightarrow 2MoO_3 + 4SO_2$

OR

$MoS_2 + 3\frac{1}{2}O_2 \rightarrow MoO_3 + 2SO_2$

Allow multiples

Ignore state symbols

1

(ii) **M1 Environmental problem**

Acid rain

OR

An effect either from acid rain or from an acidic gas in the atmosphere.

M2 Use

SO_2 could be used <u>to make / to form / to produce</u> (or wtte) H_2SO_4 / sulfuric acid

OR

<u>To make / to form / to produce</u> (or wtte) gypsum / $CaSO_4$ or plaster of Paris / plaster board

Ignore references to the greenhouse effect

Penalise reference to the ozone layer using the list principle

2

(iii) $MoO_3 + \mathbf{3}H_2 \rightarrow Mo + \mathbf{3}H_2O$

Allow multiples

Ignore state symbols

1

(iv) One from

H_2 is

- Explosive
- (in)flammable
- <u>easily</u> ignited

Ignore "burns"

1

(b) (i) To allow <u>ions</u> to <u>move</u> (when molten)

OR

<u>Ions cannot move in the solid</u>

1

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

Or multiples

Ignore state symbols

Ignore charge on the electron unless incorrect and accept loss of two electrons on the RHS

1

(iii) (High) <u>electricity</u> / <u>electrical energy</u> (cost)

Ignore "energy" and ignore "current"

[8]

6 (a) (i) $Cu + \mathbf{4}HNO_3 \longrightarrow Cu(NO_3)_2 + \mathbf{2}NO_2 + \mathbf{2}H_2O$

Or multiples

Ignore state symbols

1

(ii) **M1** HNO_3 (+) **5**

M2 NO_2 (+) **4**

Ignore working out

M1 Credit (V)

M2 Credit (IV)

2

(iii) $HNO_3 + H^+ + e^- \longrightarrow NO_2 + H_2O$

OR

$NO_3^- + 2H^+ + e^- \longrightarrow NO_2 + H_2O$

Or multiples

Ignore state symbols

Ignore charge on the electron unless incorrect and accept loss of electron on the RHS

1

(b) (i) **In either order**

M1 <u>Concentration(s)</u> (of reactants and products) <u>remain(s) constant / stay(s) the same / remain(s) the same / do(es) not change</u>

M2 <u>Forward rate = Reverse / backward rate</u>

For M1 accept [ ] for concentration

NOT "equal concentrations" and NOT "concentration(s) <u>is/are</u> the same"

NOT "amount"

Ignore "dynamic" and ignore "speed"

Ignore "closed system"

It is possible to score both marks under the heading of a single feature

2

(ii) **M1**

The (forward) reaction / to the right is endothermic
or takes in / absorbs heat

OR

The reverse reaction / to the left is exothermic or gives
out / releases heat

M2 depends on correct M1 and must refer to temperature/heat

The equilibrium shifts / moves left to right to oppose the increase in temperature

M2 depends on a correct statement for M1

For M2, the equilibrium shifts/moves

to absorb the heat OR

to lower the temperature OR

to cool the reaction

2

(iii) **M1 refers to number of moles**

There are fewer moles (of gas) on the left OR more
moles (of gas) on the right.
OR there is one mole (of gas) on the left and 2 moles
on the right.

M2 depends on correct M1 and must refer to pressure
The equilibrium shifts / moves right to left to oppose the
increase in pressure

M2 depends on a correct statement for M1

For M2, the equilibrium shifts/moves to lower the pressure.

2

[10]