M1. (a) (i) **M1** iodine ***OR*** I_2 OR I_3^-

Ignore state symbols

*Credit **M1** for "iodine solution"*

M2 $Cl_2 + \mathbf{2}I^- \longrightarrow \mathbf{2}Cl^- + I_2$

OR

$\frac{1}{2} Cl_2 + I^- \longrightarrow Cl^- + \frac{1}{2} I_2$

Penalise multiples in M2 except those shown

***M2** accept correct use of I_3^-*

M3 redox or reduction-oxidation or displacement

3

(ii) **M1** (the white precipitate is) <u>silver chloride</u>

***M1** <u>must be named</u> and for <u>this mark</u> ignore incorrect formula*

M2 $Ag^+ + Cl^- \longrightarrow AgCl$

*For **M2** ignore state symbols*

Penalise multiples

M3 (white) precipitate / <u>it dissolves</u>

OR <u>colourless solution</u>

Ignore references to "clear" alone

3

(b) (i) **M1** $H_2SO_4 + \mathbf{2}Cl^- \longrightarrow \mathbf{2}HCl + SO_4^{2-}$

*For **M1** ignore state symbols*

OR $H_2SO_4 + Cl^- \longrightarrow HCl + HSO_4^-$

Penalise multiples for equations and apply the list principle

OR $H^+ + Cl^- \longrightarrow HCl$

M2 hydrogen chloride ***OR*** HCl ***OR*** hydrochloric acid

2

(ii) **M1 and M2 in either order**

*For **M1** and **M2**, ignore state symbols and credit multiples*

M1 $\mathbf{2}I^- \longrightarrow I_2 + \mathbf{2}e^-$

OR

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

Do not penalise absence of charge on the electron

Credit electrons shown correctly on the other side of each equation

M2 $H_2SO_4 + 8H^+ + 8e^- \longrightarrow H_2S + 4H_2O$

OR

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

Additional equations should not contradict

M3 **oxidising agent / oxidises the iodide (ions)**

OR

electron acceptor

M4 **sulfur *OR* S *OR* S_2 *OR* S_8 *OR* sulphur**

4

(iii) **M1** **The NaOH / OH^- / (sodium) hydroxide reacts with / neutralises the H^+ / acid / HBr (lowering its concentration)**

OR **a correct neutralisation equation for H^+ or HBr with NaOH or with hydroxide ion**

Ignore reference to NaOH reacting with bromide ions

Ignore reference to NaOH reacting with HBrO alone

M2 **Requires a correct statement for M1**

The (position of) equilibrium moves / shifts(from L to R)

- **to replace the H^+ / acid / HBr that has been removed / lost**
- ***OR*** **to increase the H^+ / acid / HBr concentration**
- ***OR*** **to make more H^+ / acid / HBr / product(s)**
- ***OR*** **to oppose the loss of H^+ / loss of product(s)**
- ***OR*** **to oppose the decrease in concentration of product(s)**

In M2, answers must refer to the (position of) equilibrium shifts / moves and is not enough to state simply that it / the system / the reaction shifts to oppose the change.

M3 **The (health) benefit outweighs the risk or wtte**

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

3

[15]

M2. **(a)** **(i)** **$Cu + 4HNO_3 \longrightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$**

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]

M3.(a) (i) M1 0

M2 (+) 5

Accept Roman V for M2

2

(ii) $I_2 + 10H^+ + NO_3^- \rightarrow 2HI + 10N^+ + 4H_2O$

Accept multiples

1

(b) M1 $IO_3^- + 6H^+ + 5I^- \rightarrow 3I_2 + 3H_2O$

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) $H_2SO_4 + 6H^+ + 6e^- \rightarrow S + 4H_2O$

Ignore state symbols

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

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 <u>general statements</u> about Group VII trends or about halogen molecules or atoms. Answers must be specific

M1 Relative size of <u>ions</u>

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

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

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

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

***OR* <u>iodide ion(s)</u> / they have <u>greater / more shielding</u>**

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

***OR* converse for <u>chloride ion</u>**

M2 Strength of attraction for electron(s)

Must be comparative in both M1 and M2

<u>The electron(s) lost /outer shell/level electron from (an) iodide</u> ion(s) <u>less</u>

strongly held by the nucleus compared with that lost from a **chloride** ion

OR converse for a **chloride ion**

2

[15]

M4. **(a)** **(i)** $2MoS_2 + 7O_2 \rightarrow 2MoO_3 + 4SO_2$

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 to make / to form / to produce (or wtte) H_2SO_4 / sulfuric acid

OR

To make / to form / to produce (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) $MoO_3 + 3H_2 \rightarrow Mo + 3H_2O$

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

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]

M5.(a) (i) reduction OR reduced OR redox *OR* reduction–oxidation

Not "oxidation" alone

1

(ii) Fe^{3+} + $3e^-$ ⟶ Fe

Ignore state symbols
Do not penalise absence of charge on electron
Credit Fe^{3+} ⟶ *Fe – 3e*$^-$
Credit multiples

1

(b) (i) **Because (one of the following)**

CO is not the only product *OR*
Reference to "incomplete combustion to form CO" does not answer the question

(Some) complete combustion (also)occurs *OR*

CO_2 is (also) formed

Further oxidation occurs

1

(ii) **The enthalpy change / heat (energy) change at constant pressure in a reaction**
is independent of the route / path taken (and depends only on the initial and
final states)

1

(iii) **M1** **The enthalpy change / heat change at constant pressure when 1 molof a compound / substance / element**
For M1, credit correct reference to molecule/s or atom/s

M2 **is burned completely / undergoes complete combustion in (excess) oxygen**

M3 **with all reactants and products / all substances in standard states**
For M3
Ignore reference to 1 atmosphere

OR **all reactants and products / all substances in normal / specified states**
under standard conditions / 100 kPa / 1 bar and specified T / 298 K

3

(c) **M1 (could be scored by a correct mathematical expression which <u>must</u> have <u>all</u> ΔH symbols and the $\sum$)**

Correct answer gains full marks

Credit 1 mark ONLY for –1 (kJ mol^{-1})

M1 $\Delta H_r = \sum \Delta H_f$ **(products)** $- \sum \Delta H_f$ **(reactants)**

Credit 1 mark ONLY for – 27 (kJ mol^{-1}) i.e. assuming value for Fe(l) = 0

***OR* <u>correct cycle of balanced equations with 2Fe, 3C and 3O_2</u>**

M2 ΔH_r **= 2(+14) + 3(– 394) – (– 822) – 3(–111)**

= 28 –1182 + 822 + 333

(This also scores M1)

M3 = (+) 1 (kJ mol^{-1})

(Award 1 mark ONLY for – 1)

(Award 1 mark ONLY for – 27)

For other incorrect or incomplete answers, proceed as follows

- ***check for an arithmetic error (AE), which is either a transposition error or an incorrect multiplication; this would score 2 marks (M1 and M2)***
- ***If no AE, check for a correct method; this requires either a correct cycle with 2Fe, 3C and 3O_2 OR a clear statement of M1 which could be in words and scores <u>only M1</u>***

3

(d) **(i)** **C(s) + O_2(g) CO_2(g)**

State symbols essential

Possible to include C(s, graphite)

1

(ii) **These two enthalpy changes are for <u>the same reaction / same equation / same reactants and products</u>**

Penalise reference to CO_2 being produced by a different route

OR

They <u>both make one mole of carbon dioxide only from carbon and oxygen</u>
(or this idea clearly implied)

"both form CO_2" is not sufficient (since other products might occur e.g.CO)

OR

The <u>same number and same type of bonds are broken and formed</u> 1

[12]