**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** <u>oxidising agent</u> / <u>oxidises the iodide</u> (ions)

*OR*

<u>electron acceptor</u>

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

4

**(iii)** **M1** The <u>NaOH / $OH^-$ / (sodium) hydroxide reacts with / neutralises the $H^+$ / acid / HBr</u> (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) <u>equilibrium moves / shifts</u>(from L to R)

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

*In M2, answers must refer to the (position of) <u>equilibrium shifts / moves</u> 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)** $I_2 + 10HNO_3 \longrightarrow 2HI + 10NO_3 + 4H_2O$

***Accept multiples***

**1**

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

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

***Ignore state symbols***

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

***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> <u>ΔH</u> symbols and the ∑)**

***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** $\Delta H_r$ **= 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]**