Mark schemes

1 (a) $2Cl^- \longrightarrow Cl_2 + 2e^{(-)}$

Allow $2Cl^- - 2e^{(-)} \longrightarrow Cl_2$

Allow correct equation forming ClO^- *but not* Cl^+

1

(b) $2ClO^- + 4H^+ + 2e^- \longrightarrow Cl_2 + 2H_2O$

Allow HClO in correctly balanced equation

1

(c) $ClO^- + Cl^- + 2H^+ \longrightarrow Cl_2 + H_2O$

allow $HClO + HCl + \longrightarrow Cl_2 + H_2O$

1

(d) Goes brown (or shades of brown)

Allow black ppt/solid but NOT black solution or purple

1

Due to iodine or I_3^-

Correct ½ equation scores M2 and M3

1

Because I^- oxidised

1

[6]

2 C

[1]

3 C

[1]

4 B

[1]

5 (a) Increasing atomic radius / shielding / number of shells / size (down group) or reverse argument

NOT *'molecules'*

1

Decreasing attraction of <u>nucleus/protons</u> for shared (electron) pair / bond electrons

NOT *if attraction for single electron implied*

1

(b) (i) Electron acceptor / species that accepts electrons / species that gains electrons

NOT *electron pair*

NOT *just 'gain of electrons'*

1

(ii) Chlorine 0 to –1 / oxidation state/number of chlorine decreases
AND
Bromine –1 to 0 / oxidation state/number of bromine increases

Penalise if oxidised for chlorine and/or reduced for bromine

Credit oxidation states if labelled on equation

1

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

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

ALLOW *fractions/multiples*

IGNORE *state symbols*

1

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

ALLOW *fractions/multiples*

IGNORE *state symbols*

ALLOW $2I^- - 2e^{(-)} \longrightarrow I_2$

1

(iii) $H_2SO_4 + 8H^+ + 8I^- \longrightarrow H_2S + 4H_2O + 4I_2$

ALLOW

$H_2SO_4 + 8HI \longrightarrow H_2S + 4H_2O + 4I_2$

$SO_4^{2-} + 2H^+ + 8HI \longrightarrow H_2S + 4H_2O + 4I_2$

$SO_4^{2-} + 10H^+ + 8I^- \longrightarrow H_2S + 4H_2O + 4I_2$

$9H_2SO_4 + 8I^- \longrightarrow H_2S + 4H_2O + 4I_2 + 8HSO_4^-$

$9H_2SO_4 + 8NaI \longrightarrow H_2S + 4H_2O + 4I_2 + 8NaHSO_4$

$H_2SO_4 + 8H^+ + 8NaI \longrightarrow H_2S + 4H_2O + 4I_2 + 8Na^+$

$5H_2SO_4 + 8I^- \longrightarrow H_2S + 4H_2O + 4I_2 + 4SO_4^{2-}$

$5H_2SO_4 + 8NaI \longrightarrow H_2S + 4H_2O + 4I_2 + 4Na_2SO_4$

1

(iv) 'Oxidising agent' box ticked

1

(v) $H_2SO_4 + 2NaF \longrightarrow Na_2SO_4 + 2HF$
OR
$H_2SO_4 + NaF \longrightarrow NaHSO_4 + HF$

1

(vi) Fluoride less powerful reducing agent (than iodide)

OR

Fluoride less easily oxidised than iodide

Or reverse argument in either case

***NOT** general group VII trend statement*

***NOT** fluorine/F or iodine/I*

Must be comparative

1

(d) (i) $Cl_2 + H_2O \rightleftharpoons 2H^+ + Cl^- + ClO^-/HCl + HOCl$

***ALLOW** $\longrightarrow$ for $\rightleftharpoons$*

1

(ii) Equilibrium <u>shifts/moves</u> left

1

(Producing) chlorine (which) is toxic/poisonous

Mark independently

1

[13]

6 D **[1]**

7 C **[1]**

8 B **[1]**

9 D **[1]**

10 D **[1]**

11 (a) (i) $\mathbf{2}Cl^- \longrightarrow Cl_2 + \mathbf{2}e^-$

Ignore state symbols

Credit loss of electrons from LHS

Credit multiples

Do not penalise absence of charge on electron

1

(ii) +7 ***OR*** 7 ***OR*** VII ***OR*** +VII

Allow Mn^{+7} and 7+

1

(iii) $MnO_4^- + 8H^+ + 5\mathbf{e}^- \longrightarrow Mn^{2+} + 4H_2O$

Ignore state symbols

Credit loss of electrons from RHS

Credit multiples

Do not penalise absence of charge on electron

1

(b) (i) $Cl_2 + \mathbf{2}Br^- \longrightarrow \mathbf{2}Cl^- + Br_2$

OR

$\frac{1}{2}Cl_2 + Br^- \longrightarrow Cl^- + \frac{1}{2}Br_2$

One of these two equations only

Ignore state symbols

1

(ii) (Turns to) yellow / orange / brown (solution)

Penalise "red / reddish" as the only colour

Accept "red-brown" and "red-orange"

Ignore "liquid"

Penalise reference to a product that is a gas or a precipitate

1

(iii) (Chlorine) gains electron(s) / takes electron(s) / accepts electron(s) (from the bromide ions)

OR

(Chlorine) causes another species (Br^-) to lose electron(s)

Penalise "electron pair acceptor"

Not simply "causes loss of electrons"

1

(c) **M1** $2Cl_2 + 2H_2O \longrightarrow 4HCl + O_2$

$(4H^+ + 4Cl^-)$

M2 Oxidation state **−1**

Ignore state symbols

Credit multiples

***M2** consequential on HCl or Cl^- which **must** be the only chlorine-containing product in the (un)balanced equation.*

*For **M2** allow Cl^{-1} or Cl^{1-} but **not** Cl^-*

2

(d) **M1 The relative size (of the molecules / atoms)**

Chlorine is <u>smaller</u> than bromine ***OR*** has fewer electrons / electron shells

*For **M1** ignore whether it refers to molecules or atoms.*

OR It is smaller / It has a smaller atomic radius / it is a smaller molecule / atom (or converse)

***CE=0** for the clip for reference to (halide) ions or incorrect statements about relative size*

Ignore molecular mass and M_r

M2 How size of the <u>intermolecular force</u> affects energy needed

Ignore shielding

The <u>forces between</u> chlorine / Cl_2 <u>molecules</u> are weak<u>er</u> (than the forces between bromine / Br_2 <u>molecules</u>)
(or converse for bromine)
OR chlorine / Cl_2 has <u>weaker / fewer / less</u> (VdW) <u>intermolecular forces / forces between molecules</u>
(or converse for bromine)

***QoL in M2** for clear reference to the difference in size <u>of the force between molecules</u>. Reference to Van der Waals forces alone is not enough.*

*Penalise **M2** if (covalent) bonds are broken*

2

[10]

12 (a) **M1 (could be scored by a correct mathematical expression)**

M1 $\Delta H = \Sigma \Delta H_f$ **(products)** − $\Sigma \Delta H_f$ **(reactants)**

OR a correct cycle of balanced equations

M2 = 5(−635) − (−1560)

= − 3175 + 1560

(This also scores M1)

M3 = **− 1615** (kJ mol^{-1})

Award 1 mark ONLY for (+) 1615

*Correct answer to the calculation gains all of **M1**, **M2** and **M3***

Credit 1 mark for(+) 1615 (kJ mol^{-1})

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 V_2O_5 and 5CaO OR a clear statement of **M1** which could be in words and scores **only M1***

M4 Type of reaction is

- reduction
- redox
- (or accept) V_2O_5 / it / V(V) has been reduced

*In **M4** not "vanadium / V is reduced"*

M5 Major reason for expense of extraction − the answer must be about calcium

Calcium is produced / extracted by electrolysis
OR calcium is expensive to extract
OR calcium extraction uses electricity
OR calcium extraction uses large amount of energy
OR calcium is a (very) reactive metal / reacts with water or air
OR calcium needs to be extracted / does not occur native

QoL

Accept calcium is expensive "to produce" but not "to source, to get, to obtain, to buy" etc.

*In **M5** it is neither enough to say that calcium is "expensive" nor that calcium "must be purified"*

5

(b) **M1**

$2Al + Fe_2O_3 \longrightarrow 2Fe + Al_2O_3$

Ignore state symbols

Credit multiples of the equation

M2

(Change in oxidation state) **0** to (+)**3**

OR

(changed by) **+3**

*In **M2** if an explanation is given it must be correct and unambiguous*

2

(c) **M1**

$VCl_2 + H_2 \longrightarrow V + 2HCl$

*In **M1** credit multiples of the equation*

M2 and **M3**

Two hazards in either order

- HCl / hydrogen chloride / hydrochloric acid is acidic / corrosive / toxic / poisonous
- Explosion risk with hydrogen (gas) OR H_2 is flammable

*For **M2 / M3** there must be reference to hydrogen; it is not enough to refer simply to an explosion risk*

*For **M2 / M3** with HCl hazard, require reference to acid(ic) / corrosive / toxic only*

M4

The only other product / the HCl is easily / readily removed / lost / separated because it is a gas *OR* will escape (or this idea strongly implied) as a gas
OR vanadium / it is the only solid product (and is easily separated)
OR vanadium / it is a solid and the other product / HCl is a gas

*In **M4** it is not enough to state simply that HCl is a gas, since this is in the question.*

4

[11]

13

(a) $Cl_2 + H_2O \rightleftharpoons HOCl + HCl$

Allow the products shown as ions.

1

Cl_2 = 0, HOCl = +1 and HCl = −1

1 mark for all three oxidation states correct. Allow a reaction arrow in this equation.

Oxidation states must match the species

1

(b) Hydroxide / alkali ions react with the acids

Mark independently

1

Equilibrium moves to the right

1

(c) Only used in small amounts

1

The health benefits outweigh the risks

1

[6]

14 (a) (i) **3**Fe + Sb_2S_3 ⟶ **3**FeS + **2**Sb

Or multiples.

Ignore state symbols.

1

(ii) Fe ⟶ Fe^{2+} + $2e^-$

Ignore charge on the electron unless incorrect.

Or multiples.

Credit the electrons being subtracted on the LHS.

Ignore state symbols.

1

(b) (i) Sb_2S_3 + **4.5**O_2 ⟶ Sb_2O_3 + **3**SO_2

Or multiples.

Ignore state symbols.

1

(ii) SO_3 or sulfur trioxide / sulfur (VI) oxide

Credit also the following ONLY.

H_2SO_4 or sulfuric acid.

OR

Gypsum / $CaSO_4$ or plaster of Paris.

1

(c) (i) **M1 (could be scored by a correct mathematical expression)**

Correct answer gains full marks.

M1 $\underline{\Delta H_r = \Sigma\Delta H_f(\textbf{products}) - \Sigma\Delta H_f(\textbf{reactants})}$

OR a <u>correct cycle of balanced equations / correct numbers of moles</u>

Credit 1 mark for +104 (kJ mol^{-1}).

M2 = 2(+20) + 3(−394) − (−705) − 3(−111)

= 40 −1182 + 705 + 333

= −1142 − (−1038)

(This also scores M1)

M3 = **<u>−104</u>** (kJ mol^{-1})

(Award 1 mark ONLY for + 104)

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.*
- *If no AE, check for a correct method; this requires either a correct cycle with 3CO, 2Sb and 3CO_2 OR a clear statement of **M1** which could be in words and scores **only M1**.*

3

(ii) It / Sb is <u>not in its standard state</u>

OR

<u>Standard state</u> (for Sb) <u>is solid / (s)</u>

OR

<u>(Sb) liquid is not its standard state</u>

Credit a correct definition of standard state as an alternative to the words 'standard state'.

QoL

1

(iii) Reduction **OR** reduced **OR** redox

1

(d) Low-grade ore extraction / it

- uses (cheap) scrap / waste iron / steel
- is a single-step process

uses / requires less / low(er) energy

Ignore references to temperature / heat or labour or technology.

1

[10]

15 (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

$8I^- \longrightarrow 4\mathbf{I}_2 + 8e^-$

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]