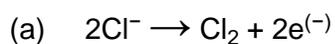


Mark schemes

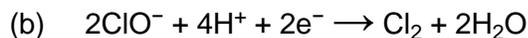
1



Allow $2\text{Cl}^- - 2\text{e}^{(-)} \rightarrow \text{Cl}_2$

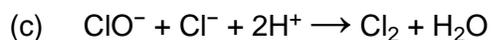
Allow correct equation forming ClO^- but not Cl^+

1



Allow HClO in correctly balanced equation

1



allow $\text{HClO} + \text{HCl} + \rightarrow \text{Cl}_2 + \text{H}_2\text{O}$

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 $\frac{1}{2}$ 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 nucleus/protons 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) $\text{H}_2\text{SO}_4 + 8\text{H}^+ + 8\text{e}^{(-)} \rightarrow \text{H}_2\text{S} + 4\text{H}_2\text{O}$
ALLOW $\text{SO}_4^{2-} + 10\text{H}^+ + 8\text{e}^{(-)} \rightarrow \text{H}_2\text{S} + 4\text{H}_2\text{O}$
ALLOW fractions/multiples
IGNORE state symbols

1

- (ii) $2\text{I}^- \rightarrow \text{I}_2 + 2\text{e}^{(-)}$
ALLOW fractions/multiples
IGNORE state symbols
ALLOW $2\text{I}^- - 2\text{e}^{(-)} \rightarrow \text{I}_2$

1

- (iii) $\text{H}_2\text{SO}_4 + 8\text{H}^+ + 8\text{I}^- \rightarrow \text{H}_2\text{S} + 4\text{H}_2\text{O} + 4\text{I}_2$
ALLOW
 $\text{H}_2\text{SO}_4 + 8\text{HI} \rightarrow \text{H}_2\text{S} + 4\text{H}_2\text{O} + 4\text{I}_2$
 $\text{SO}_4^{2-} + 2\text{H}^+ + 8\text{HI} \rightarrow \text{H}_2\text{S} + 4\text{H}_2\text{O} + 4\text{I}_2$
 $\text{SO}_4^{2-} + 10\text{H}^+ + 8\text{I}^- \rightarrow \text{H}_2\text{S} + 4\text{H}_2\text{O} + 4\text{I}_2$
 $9\text{H}_2\text{SO}_4 + 8\text{I}^- \rightarrow \text{H}_2\text{S} + 4\text{H}_2\text{O} + 4\text{I}_2 + 8\text{HSO}_4^-$
 $9\text{H}_2\text{SO}_4 + 8\text{NaI} \rightarrow \text{H}_2\text{S} + 4\text{H}_2\text{O} + 4\text{I}_2 + 8\text{NaHSO}_4$
 $\text{H}_2\text{SO}_4 + 8\text{H}^+ + 8\text{NaI} \rightarrow \text{H}_2\text{S} + 4\text{H}_2\text{O} + 4\text{I}_2 + 8\text{Na}^+$
 $5\text{H}_2\text{SO}_4 + 8\text{I}^- \rightarrow \text{H}_2\text{S} + 4\text{H}_2\text{O} + 4\text{I}_2 + 4\text{SO}_4^{2-}$
 $5\text{H}_2\text{SO}_4 + 8\text{NaI} \rightarrow \text{H}_2\text{S} + 4\text{H}_2\text{O} + 4\text{I}_2 + 4\text{Na}_2\text{SO}_4$

1

- (iv) 'Oxidising agent' box ticked

1

- (v) $\text{H}_2\text{SO}_4 + 2\text{NaF} \rightarrow \text{Na}_2\text{SO}_4 + 2\text{HF}$
OR
 $\text{H}_2\text{SO}_4 + \text{NaF} \rightarrow \text{NaHSO}_4 + \text{HF}$

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) $\text{Cl}_2 + \text{H}_2\text{O} \rightleftharpoons 2\text{H}^+ + \text{Cl}^- + \text{ClO}^-/\text{HCl} + \text{HOCl}$

ALLOW \rightarrow for \rightleftharpoons

1

(ii) Equilibrium shifts/moves left

1

(Producing) chlorine (which) is toxic/poisonous

Mark independently

1

[13]

6 D

[1]

7 C

[1]

8 B

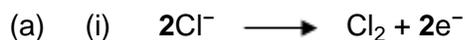
[1]

9 D

[1]

10 D

[1]

11*Ignore state symbols**Credit loss of electrons from LHS**Credit multiples**Do not penalise absence of charge on electron*

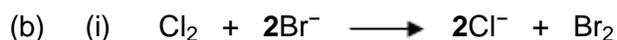
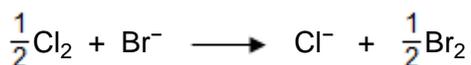
1

*Allow Mn^{+7} and 7+*

1

*Ignore state symbols**Credit loss of electrons from RHS**Credit multiples**Do not penalise absence of charge on electron*

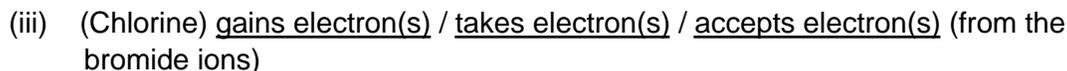
1

**OR***One of these two equations only**Ignore state symbols*

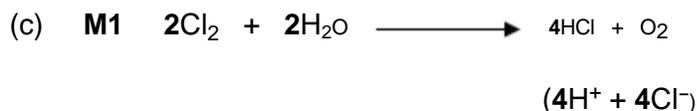
1

*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

**OR***Penalise "electron pair acceptor"**Not simply "causes loss of electrons"*

1



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 Cl¹⁻ but **not** Cl⁻

2

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

Chlorine is smaller 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 intermolecular force affects energy needed

Ignore shielding

The forces between chlorine / Cl₂ molecules are weaker (than the forces between bromine / Br₂ molecules)

(or converse for bromine)

OR chlorine / Cl₂ has weaker / fewer / less (VdW) intermolecular forces / forces between molecules

(or converse for bromine)

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

Penalise M2 if (covalent) bonds are broken

2

[10]

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

M1 $\Delta H = \sum \Delta H_f(\text{products}) - \sum \Delta H_f(\text{reactants})$

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"*

- (b) **M1**
 $2\text{Al} + \text{Fe}_2\text{O}_3 \longrightarrow 2\text{Fe} + \text{Al}_2\text{O}_3$
 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**
 $\text{VCl}_2 + \text{H}_2 \longrightarrow \text{V} + 2\text{HCl}$
 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 H₂ 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) $\text{Cl}_2 + \text{H}_2\text{O} = \text{HOCl} + \text{HCl}$
 Allow the products shown as ions.

1

$\text{Cl}_2 = 0$, $\text{HOCl} = +1$ and $\text{HCl} = -1$

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

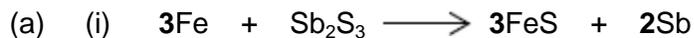
1

The health benefits outweigh the risks

1

[6]

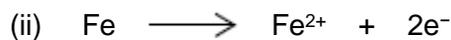
14



Or multiples.

Ignore state symbols.

1



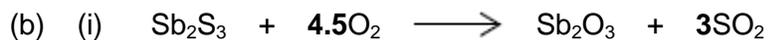
Ignore charge on the electron unless incorrect.

Or multiples.

Credit the electrons being subtracted on the LHS.

Ignore state symbols.

1



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.

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

OR a correct cycle of balanced equations / correct numbers of moles

Credit 1 mark for +104 (kJ mol⁻¹).

$$\mathbf{M2} \quad = 2(+20) + 3(-394) - (-705) - 3(-111)$$

$$= 40 - 1182 + 705 + 333$$

$$= -1142 - (-1038)$$

(This also scores M1)

$$\mathbf{M3} \quad = \underline{-104} \text{ (kJ mol}^{-1}\text{)}$$

(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 3CO₂ OR a clear statement of **M1** which could be in words and scores **only M1**.*

3

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

OR

Standard state (for Sb) is solid / (s)

OR

(Sb) liquid is not its standard state

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 $\text{Cl}_2 + 2\text{e}^- \longrightarrow 2\text{Cl}^-$

Credit 1 or 2 electrons but not lone pair.

The idea of 'reduction' alone is not enough.

1

(b) (i) $6\text{KI} + 7\text{H}_2\text{SO}_4 \longrightarrow 6\text{KHSO}_4 + 3\text{I}_2 + \text{S} + 4\text{H}_2\text{O}$

1

(ii) $2\text{I}^- \longrightarrow \text{I}_2 + 2\text{e}^-$

OR

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

Ignore charge on the electron unless incorrect.

Or multiples.

Credit the electrons being subtracted on the LHS.

Ignore state symbols.

1

(iii) $\text{H}_2\text{SO}_4 + 8\text{H}^+ + 8\text{e}^- \longrightarrow \text{H}_2\text{S} + 4\text{H}_2\text{O}$

OR

$\text{SO}_4^{2-} + 10\text{H}^+ + 8\text{e}^- \longrightarrow \text{H}_2\text{S} + 4\text{H}_2\text{O}$

Ignore charge on the electron unless incorrect.

Or multiples.

Credit the electrons being subtracted on the RHS.

Ignore state symbols.

1



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



OR



OR



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]