

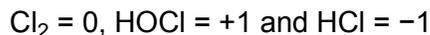
Mark schemes

1



Allow the products shown as ions.

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

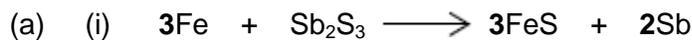
1

The health benefits outweigh the risks

1

[6]

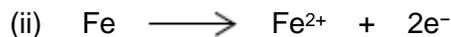
2



Or multiples.

Ignore state symbols.

1



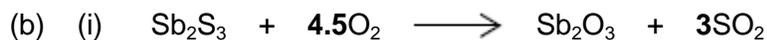
Ignore charge on the electron unless incorrect.

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.

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

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

Credit 1 mark for +104 (kJ mol⁻¹).

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

= 40 - 1182 + 705 + 333

= -1142 - (-1038)

(This also scores M1)

M3 = -104 (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 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

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3

(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

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

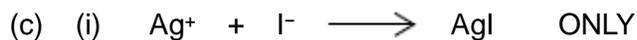
Ignore charge on the electron unless incorrect.

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

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4

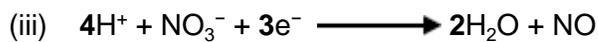


1

(ii) **(+) 5**

(+) 2

2

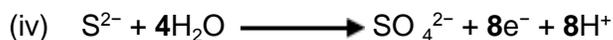


Ignore state symbols.

*Credit multiples of **this equation only**.*

Ignore absence of charge on the electron.

1



Ignore state symbols.

*Credit multiples of **this equation only**.*

Ignore absence of charge on the electron.

1

(b) M1 add scrap / recycled / waste iron (or steel) 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 more reactive metal **OR** Fe is a better reducing agent
Credit zinc or magnesium as an alternative to iron for M2, M3 and M4 only, penalising M1

M3 Cu^{2+} / copper ions are reduced / gain electrons
OR $\text{Cu}^{2+} + 2\text{e}^- \longrightarrow \text{Cu}$
OR copper / Cu is displaced by Fe
Ignore absence of charge on the electron.

M4 $\text{Fe} + \text{Cu}^{2+} \longrightarrow \text{Fe}^{2+} + \text{Cu}$ ONLY
For M4, ignore state symbols

4

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5

(a) $2\text{Ca}_5\text{F}(\text{PO}_4)_3 + 9\text{SiO}_2 + 15\text{C} \longrightarrow 9\text{CaSiO}_3 + \text{CaF}_2 + 15\text{CO} + 6\text{P}$

1

(b) M1 ($\text{P}_4 =$) 0

M2 ($\text{H}_3\text{PO}_4 =$) (+) 5

Accept Roman numeral V for M2

2

(c) H_2SO_4

Both numbers required

$$\begin{aligned} M_r &= 2(1.00794) + 32.06550 + 4(15.99491) \\ &= \mathbf{98.06102} \text{ or } \mathbf{98.0610} \text{ or } \mathbf{98.061} \text{ or } \mathbf{98.06} \text{ or } \mathbf{98.1} \end{aligned}$$

Calculations not required

and

H_3PO_4

$$\begin{aligned} M_r &= 3(1.00794) + 30.97376 + 4(15.99491) \\ &= \mathbf{97.97722} \text{ or } \mathbf{97.9772} \text{ or } \mathbf{97.977} \text{ or } \mathbf{97.98} \text{ or } \mathbf{98.0} \end{aligned}$$

1

(d) (i) A substance that speeds up a reaction **OR** alters / increases the rate of a reaction **AND** is chemically unchanged at the end / not used up.

Both ideas needed

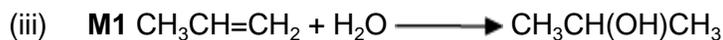
Ignore reference to activation energy or alternative route.

1

(ii) The addition of water (**QoL**) to a molecule / compound

QoL- for the underlined words

1



For **M1** insist on correct structure for the alcohol but credit correct equations using either C_3H_6 or double bond not given.

M2 propan-2-ol

2

[8]

6

(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"

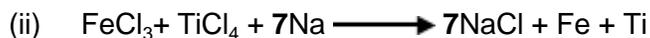
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Ignore state symbols

Credit multiples

1



OR (for example)



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 $\text{Cu}^{2+} + 2\text{e}^- \longrightarrow \text{Cu}$

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) $2\text{O}^{2-} \longrightarrow \text{O}_2 + 4\text{e}^-$

Or multiples including

$3\text{O}^{2-} \longrightarrow 1.5 \text{O}_2 + 6\text{e}^-$

Ignore state symbols

Ignore charge on the electron

Credit the electrons being subtracted on the LHS

1

[6]

7

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

Ignore state symbols

Credit M1 for "iodine solution"

M2 $\text{Cl}_2 + 2\text{I}^- \longrightarrow 2\text{Cl}^- + \text{I}_2$

OR

$\frac{1}{2} \text{Cl}_2 + \text{I}^- \longrightarrow \text{Cl}^- + \frac{1}{2} \text{I}_2$

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) silver chloride
M1 must be named and for this mark ignore incorrect formula

M2 $\text{Ag}^+ + \text{Cl}^- \longrightarrow \text{AgCl}$
For M2 ignore state symbols
Penalise multiples

M3 (white) precipitate / it dissolves

OR colourless solution
Ignore references to "clear" alone

3

(b) (i) **M1** $\text{H}_2\text{SO}_4 + 2\text{Cl}^- \longrightarrow 2\text{HCl} + \text{SO}_4^{2-}$
For M1 ignore state symbols

OR $\text{H}_2\text{SO}_4 + \text{Cl}^- \longrightarrow \text{HCl} + \text{HSO}_4^-$
Penalise multiples for equations and apply the list principle

OR $\text{H}^+ + \text{Cl}^- \longrightarrow \text{HCl}$

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

OR

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

Do not penalise absence of charge on the electron

Credit electrons shown correctly on the other side of each equation

M2 $\text{H}_2\text{SO}_4 + 8\text{H}^+ + 8\text{e}^- \longrightarrow \text{H}_2\text{S} + 4\text{H}_2\text{O}$

OR

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

Additional equations should not contradict

M3 oxidising agent / oxidises the iodide (ions)

OR

electron acceptor

M4 sulfur **OR** S **OR** S₂ **OR** S₈ **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]

8



Ignore state symbols

Credit multiples of either equation

OR



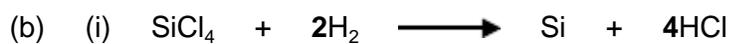
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(ii) (fractional) distillation

OR

G(L)C or gas (–liquid–) chromatography

1



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

readily / easily ignites / burns / combusts

1



Ignore state symbols

Credit multiples

1

[6]