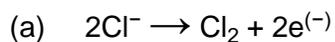


Mark schemes

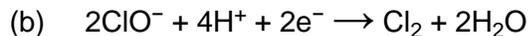
1



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

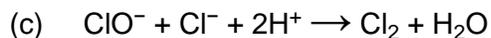
Allow correct equation forming ClO^- but not Cl^+

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

(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

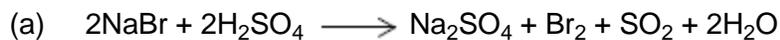
(Producing) chlorine (which) is toxic/poisonous

Mark independently

1

[13]

3



Allow ionic equation



1

Br^- ions are bigger than Cl^- ions

1

Therefore Br^- ions more easily oxidised / lose an electron more easily (than Cl^- ions)

1

- (b) This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.

Level 3

All stages are covered and the explanation of each stage is generally correct and virtually complete. Stages 1 and 2 are supported by correct equations.

Answer communicates the whole process coherently and shows a logical progression from stage 1 to stage 2 and then stage 3. The steps in stage 3 are in a logical order.

5–6 marks

Level 2

All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies OR two stages are covered and the explanations are generally correct and virtually complete.

Answer is mainly coherent and shows a progression through the stages. Some steps in each stage may be out of order and incomplete.

3–4 marks

Level 1

Two stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies, OR only one stage is covered but the explanation is generally correct and virtually complete.

Answer includes some isolated statements, but these are not presented in a logical order or show confused reasoning.

1–2 marks

Level 0

Insufficient correct chemistry to warrant a mark.

0 marks

Indicative chemistry content

Stage 1: formation of precipitates

- Add silver nitrate
- to form precipitates of AgCl and AgBr
- $\text{AgNO}_3 + \text{NaCl} \rightarrow \text{AgCl} + \text{NaNO}_3$
- $\text{AgNO}_3 + \text{NaBr} \rightarrow \text{AgBr} + \text{NaNO}_3$

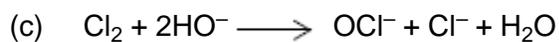
Stage 2: selective dissolving of AgCl

- Add excess of dilute ammonia to the mixture of precipitates
- the silver chloride precipitate dissolves
- $\text{AgCl} + 2\text{NH}_3 \rightarrow \text{Ag}(\text{NH}_3)_2^+ + \text{Cl}^-$

Stage 3: separation and purification of AgBr

- Filter off the remaining silver bromide precipitate
- Wash to remove soluble compounds
- Dry to remove water

6



1

OCl⁻ is +1

Cl⁻ is -1

Both required for the mark

1

[11]

4

D

[1]

5

D

[1]

6

(a) Q is calcium or magnesium

1

bromide

1

R is aluminium

1

chloride

1

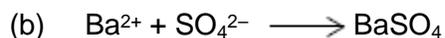
S is iron(III)

1

sulfate

1

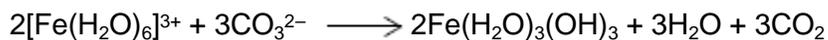
Mark this question independently



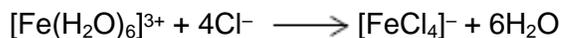
1



1



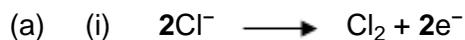
1



1

[10]

7



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



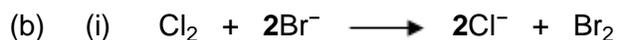
Ignore state symbols

Credit loss of electrons from RHS

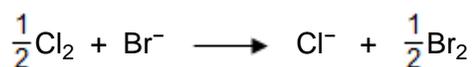
Credit multiples

Do not penalise absence of charge on electron

1



OR



One of these two equations only

Ignore state symbols

1

(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)

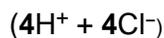
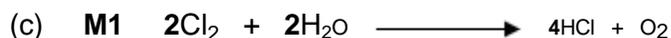
OR

(Chlorine) causes another species (Br⁻) to lose electron(s)

Penalise "electron pair acceptor"

Not simply "causes loss of electrons"

1



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 / Cl_2 molecules are weaker (than the forces between bromine / Br_2 molecules)

(or converse for bromine)

OR chlorine / Cl_2 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]

8

(a) **M1** acidified potassium dichromate or $K_2Cr_2O_7 / H_2SO_4$

OR $K_2Cr_2O_7 / H^+$ **OR** acidified $K_2Cr_2O_7$

M2 (orange to) green solution **OR** goes green

M3 (solution) remains orange or no reaction or no (observed) change

*If no reagent or incorrect reagent in **M1**, **CE = 0** and no marks for **M1**, **M2** or **M3***

*If incomplete / inaccurate attempt at reagent e.g. "dichromate" or "dichromate(IV)" or incorrect formula or no acid, **penalise M1 only and mark on***

*For **M2** ignore dichromate described as "yellow" or "red"*

*For **M3** ignore "nothing (happens)" or "no observation"*

Alternative using $KMnO_4 / H_2SO_4$

M1 acidified potassium manganate(VII) / potassium permanganate or $KMnO_4 / H_2SO_4$

OR $KMnO_4 / H^+$ **OR** acidified $KMnO_4$

M2 colourless solution **OR** goes colourless

M3 (solution) remains purple or no reaction or no (observed) change

*For **M1***

*If incomplete / inaccurate attempt at reagent e.g. "manganate" or "manganate(IV)" or incorrect formula or no acid, **penalise M1 only and mark on***

*Credit alkaline $KMnO_4$ for possible full marks but **M2** gives brown precipitate or solution goes green*

(b) **M1** (Shake with) Br₂ **OR** bromine (water) **OR** bromine (in CCl₄ / organic solvent)

M2 (stays) orange / red / yellow / brown / the same

OR no reaction **OR** no (observed) change

M3 decolourised / goes colourless / loses its colour / orange to colourless

*If no reagent or incorrect reagent in **M1**, **CE = 0** and no marks for **M1**, **M2** or **M3***

*If incomplete / inaccurate attempt at reagent (e.g. Br), **penalise M1 only and mark on***

*No credit for combustion observations; **CE = 0***

*For **M2** in every case*

Ignore “nothing (happens)”

Ignore “no observation”

Ignore “clear”

OR as alternatives

Use KMnO₄ / H₂SO₄

M1 acidified potassium manganate(VII) / potassium permanganate **OR**
KMnO₄ / H₂SO₄

OR KMnO₄ / H⁺ **OR** acidified KMnO₄

M2 (stays) purple or no reaction or no (observed) change

M3 decolourised / goes colourless / loses its colour

Use iodine

M1 iodine or I₂ / KI or iodine solution

M2 no change

M3 decolourised / goes colourless / loses its colour

Use concentrated sulfuric acid

M1 concentrated H₂SO₄

M2 no change

M3 brown

*For **M1**, it must be a whole reagent and / or correct formula*

*For **M1** penalise incorrect attempt at correct formula, but mark **M2** and **M3***

With potassium manganate(VII)

*If incomplete / inaccurate attempt at reagent e.g. “manganate” or “manganate(IV)” or incorrect formula or no acid, **penalise M1 only and mark on***

*Credit alkaline / neutral KMnO_4 for possible full marks but **M3** gives brown precipitate or solution goes green*

Apply similar guidance for errors in the formula of iodine or concentrated sulfuric acid reagent as those used for other reagents.

(c) **M1** Any soluble chloride including hydrochloric acid (ignore concentration)

M2 white precipitate or white solid / white suspension

M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

OR as an alternative

M1 Any soluble iodide including HI

M2 yellow precipitate or yellow solid / yellow suspension

M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

OR as an alternative

M1 Any soluble bromide including HBr

M2 cream precipitate or cream solid / cream suspension

M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

OR as an alternative

M1 NaOH or KOH or any soluble carbonate

M2 brown precipitate or brown solid / brown suspension with NaOH / KOH
(white precipitate / solid / suspension with carbonate)

M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

*If no reagent or incorrect reagent or insoluble chloride in **M1**, **CE = 0**
and no marks for **M1**, **M2** or **M3***

Allow chlorine water

*If incomplete reagent (e.g. chloride ions) or inaccurate attempt at
formula of chosen chloride, or chlorine, **penalise M1 only and
mark on***

*For **M2** require the word "white" and some reference to a solid.
Ignore "cloudy solution" OR "suspension" (similarly for the
alternatives)*

*For **M3***

Ignore "nothing (happens)"

Ignore "no observation"

Ignore "clear" on its own

Ignore "dissolves"

(d) **M1** Any soluble sulfate including (dilute or aqueous) sulfuric acid

M2 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

M3 white precipitate or white solid / white suspension

*If no reagent or incorrect reagent or insoluble sulfate in **M1**, **CE = 0** and no marks for **M1**, **M2** or **M3***

Accept $MgSO_4$ and $CaSO_4$ but not barium, lead or silver sulfates

*If concentrated sulfuric acid or incomplete reagent (e.g. sulfate ions) or inaccurate attempt at formula of chosen sulfate, **penalise M1 only and mark on***

*For **M3** (or **M2** in the alternative) require the word “white” and some reference to a solid.*

Ignore “cloudy solution” OR “suspension”

*For **M2** (or **M3** in the alternative)*

Ignore “nothing (happens)”

Ignore “no observation”

Ignore “clear” on its own

Ignore “dissolves”

OR as an alternative

M1 NaOH or KOH

M2 white precipitate or white solid / white suspension

M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

*If incomplete reagent (e.g. hydroxide ions) or inaccurate attempt at formula of chosen hydroxide, **penalise M1 only and mark on***

*If **M1** uses NH_3 (dilute or concentrated) **penalise M1 only and mark on***

3

[12]

9

(a) $Cl_2 + H_2O = HOCl + HCl$

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]

10

(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

(c) (i) $\text{Ag}^+ + \text{I}^- \longrightarrow \text{AgI}$ 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



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]