



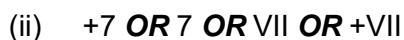
Ignore state symbols

Credit loss of electrons from LHS

Credit multiples

Do not penalise absence of charge on electron

1



Allow Mn^{+7} and 7+

1



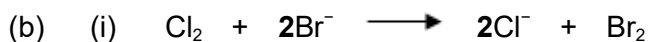
Ignore state symbols

Credit loss of electrons from RHS

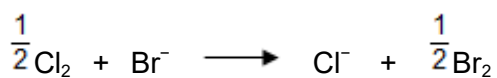
Credit multiples

Do not penalise absence of charge on electron

1



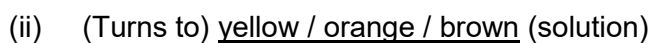
OR



One of these two equations only

Ignore state symbols

1



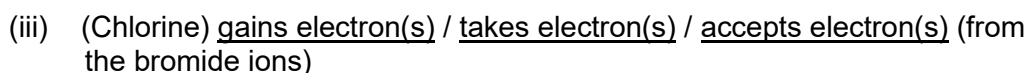
Penalise "red / reddish" as the only colour

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

Ignore "liquid"

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

1



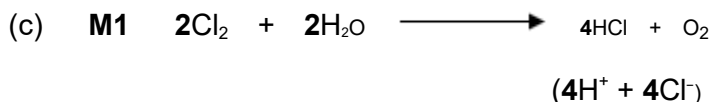
OR



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^- or Cl^- 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]

M2.(a) **M1** concentrated sulfuric acid OR c(onc) H_2SO_4

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

M2 (cream solid) turns orange

OR orange / red / brown fumes / gas / vapour

*If dilute sulfuric acid **OR** "aq" (alone) CE=0*

M3 (yellow solid) turns black

OR purple fumes / gas / vapour

OR correct reference to H₂S observation (eg bad egg smell)

*If H₂SO₄ / sulfuric acid given but not stated whether dilute or concentrated, penalise **M1** and mark on for **M2** and **M3***

*If incorrect formula for the acid, penalise **M1** but mark **M2** and **M3***

OR as an alternative

M1 concentrated ammonia **OR** c(onc) NH₃

*If NH₃ / ammonia / aq ammonia given, but not stated as concentrated **OR** if dilute ammonia given, penalise **M1** but mark on for **M2** and **M3***

*Ignore “partially” and ignore “clear” in **M2***

M2 (cream solid) dissolves / solution formed

M3 precipitate remains / does not dissolve / insoluble

OR no reaction / no change / (yellow solid) turns to white solid

*If incorrect formula for ammonia, penalise **M1** but mark **M2** and **M3***

*In **M3** for ammonia.*

ignore “nothing (happens)”.

ignore “no observation”.

3

(b) M1 AgNO₃ **OR** silver nitrate **OR** any soluble silver salt

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

M2 white precipitate or white solid / white suspension

*An insoluble silver salt **OR** Tollens’ **OR** Ag **OR** ammoniacal silver nitrate or HCl / AgNO₃ **CE= 0** for the clip.*

M3 remains colourless **OR** no reaction **OR** no (observed) change **OR** no precipitate

*For **M1***

*Credit acidified (**OR** HNO₃) silver nitrate for **M1** and mark on.*

If silver ions or incorrect formula for silver nitrate, penalise

M1** but mark **M2** and **M3

Credit alternative test for nitrate ions

*For **M2***

*Ignore “cloudy solution” **OR** “suspension”.*

*For **M3***

Ignore “nothing (happens)”.

Ignore “no observation”.

Ignore “clear”.

Ignore “dissolves”.

3

- (c) M1 Br₂ **OR** bromine (water) **OR** bromine (in CCl₄ / organic solvent)
If no reagent or incorrect reagent in M1, CE= 0 and no marks for M2 or M3

Either Order

- M2 (stays) Orange / red / yellow / brown / the same
OR no reaction **OR** no (observed) change
OR reference to colour going to cyclohexane layer

No credit for combustion observations; CE=0

For M2 in every case.

Ignore "nothing (happens)".

Ignore "no observation".

Ignore "clear".

- M3 decolourised / goes colourless / loses its colour

With bromine (water)

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

If oxidation state given in name, it must be correct.

For M1 penalise incorrect formula, but mark M2 and M3

OR as an alternative

Use KMnO₄/H₂SO₄

- M1 acidified potassium manganate(VII) or KMnO₄/H₂SO₄

OR KMnO₄/ H⁺ **OR** acidified KMnO₄

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

With potassium manganate(VII)

For M1

- M3 purple to colourless solution **OR** goes colourless

If "manganate" or "manganate(IV)" or incorrect formula or no acid, penalise M1 but mark M2 and M3

Credit alternative test using **iodine** (for M1)

- M2 (brown) to purple or accept no change, M3 colourless

Credit alternative test using concentrated H₂ SO₄

- M2 no change, M3 brown

Credit alkaline / neutral KMnO₄ for possible full marks but M3 gives brown precipitate or solution goes green.

3

- (d) M1 Tollens' (reagent) OR ammoniacal silver nitrate OR a description of making Tollens'
(Ignore either AgNO₃ or [Ag(NH₃)₂]⁺ or "the silver mirror test" on their own, but mark M2 and M3)

M2 silver mirror

OR black solid / precipitate (Ignore silver precipitate)

- M3 (stays) colourless or no reaction or no (observed) change

If no reagent or incorrect reagent in M1, CE= 0 and no marks

for **M2** or **M3**

For M3 in every case

Ignore “nothing (happens)”.

Ignore “no observation”.

Alternative using Fehling’s (solution)

M1 Fehling’s (solution) or Benedict’s solution

(Ignore $\text{Cu}^{2+}(\text{aq})$ or CuSO_4 on their own, but mark M2 and M3)

M2 Red solid / precipitate (Credit Orange or brown solid)

M3 (stays) blue or no reaction or no (observed) change

With potassium dichromate(VI)

For M1

If “dichromate” or “(potassium) dichromate(IV)” or incorrect formula or no acid, penalise **M1** but mark **M2** and **M3**

Alternative using $\text{K}_2\text{Cr}_2\text{O}_7/\text{H}_2\text{SO}_4$

M1 acidified potassium dichromate or $\text{K}_2\text{Cr}_2\text{O}_7/\text{H}_2\text{SO}_4$

OR $\text{K}_2\text{Cr}_2\text{O}_7/\text{H}^+$ **OR** acidified $\text{K}_2\text{Cr}_2\text{O}_7$

M2 (Orange to) green solution OR goes green

M3 (stays) Orange or no reaction or no (observed) change

For M3

Ignore dichromate described as “yellow” or “red”.

With potassium manganate(VII)

For M1

If “manganate” or “(potassium manganate(IV))” or incorrect formula or no acid, penalise M1 but mark M2 and M3

Alternative using $\text{KMnO}_4/\text{H}_2\text{SO}_4$

M1 acidified potassium manganate(VII) or $\text{KMnO}_4/\text{H}_2\text{SO}_4$

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

M2 purple to colourless solution OR goes colourless

M3 (stays) purple or no reaction or no (observed) change

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

3

[12]

M3.(a) **M1** acidified potassium dichromate or $\text{K}_2\text{Cr}_2\text{O}_7/\text{H}_2\text{SO}_4$

OR $\text{K}_2\text{Cr}_2\text{O}_7/\text{H}^+$ **OR** acidified $\text{K}_2\text{Cr}_2\text{O}_7$

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 $\text{KMnO}_4 / \text{H}_2\text{SO}_4$

M1 acidified potassium manganate(VII) / potassium permanganate or $\text{KMnO}_4 / \text{H}_2\text{SO}_4$

OR $\text{KMnO}_4 / \text{H}^+$ **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*

3

(b) **M1** (Shake with) Br_2 **OR** bromine (water) **OR** bromine (in CCl_4 / 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 $\text{KMnO}_4 / \text{H}_2\text{SO}_4$

M1 acidified potassium manganate(VII) / potassium permanganate **OR** $\text{KMnO}_4 / \text{H}_2\text{SO}_4$

OR $\text{KMnO}_4 / \text{H}^+$ **OR** acidified KMnO_4

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 KMnO₄ 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.

3

(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”

3

(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]



Allow multiples, including fractions.

Allow ionic equations.

Lose this mark if any of the state symbols are missing or incorrect.

1

(ii) Add nitric acid to the mixture (until in excess)

Do not allow any suggestion that the solution is an emetic.

1

Filter (to isolate strontium sulfate)

1

(b) Insoluble barium sulfate is formed

Allow 'removes barium ions as a precipitate'.

1

(c) Add silver nitrate, then dilute ammonia (solution) **M1**

Do not allow answers which imply silver nitrate and ammonia are added at the same time.

Allow 'add silver nitrate, then concentrated ammonia (solution)'.

*Can score **M1** in the answer for **M3***

1

Cream precipitate **M2**

Allow 'off white precipitate'.

1

No visible change or precipitate dissolves slightly in dilute ammonia **M3**

Allow 'soluble / colourless solution / precipitate dissolves in concentrated ammonia'.

Allow 3 marks for:

*Add dilute ammonia (solution), then silver nitrate **M1***

*No visible change **M2***

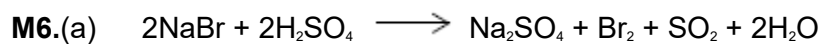
*Cream / off white precipitate with silver nitrate **M3***

1

[7]

M5.D

[1]



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*
- $\text{AgNO}_3 + \text{NaCl} \rightarrow \text{AgCl} + \text{NaNO}_3$
- $\text{AgNO}_3 + \text{NaBr} \rightarrow \text{AgBr} + \text{NaNO}_3$

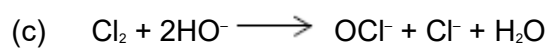
Stage 2: selective dissolving of AgCl

- *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]