



*Ignore state symbols*

*Credit loss of electrons from LHS*

*Credit multiples*

*Do not penalise absence of charge on electron*

1



*Allow  $\text{Mn}^{+7}$  and 7+*

1



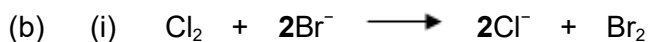
*Ignore state symbols*

*Credit loss of electrons from RHS*

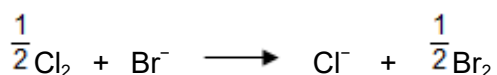
*Credit multiples*

*Do not penalise absence of charge on electron*

1



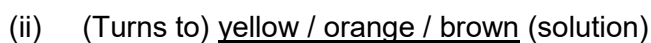
**OR**



*One of these two equations only*

*Ignore state symbols*

1



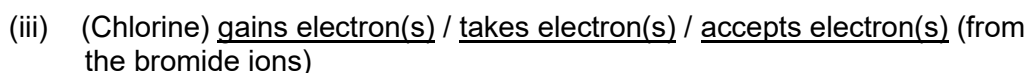
*Penalise "red / reddish" as the only colour*

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

*Ignore "liquid"*

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

1



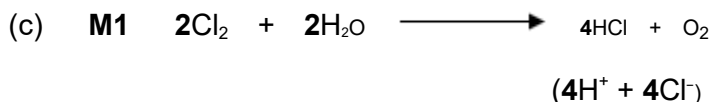
**OR**



*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  $\text{Cl}^-$  which **must** be the only chlorine-containing product in the (un)balanced equation.

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

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 /  $\text{Cl}_2$  molecules are weaker (than the forces between bromine /  $\text{Br}_2$  molecules)

(or converse for bromine)

**OR** chlorine /  $\text{Cl}_2$  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)  $\text{H}_2\text{SO}_4$

*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  $H_2S$  observation (eg bad egg smell)

*If  $H_2SO_4$  / 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)  $NH_3$

*If  $NH_3$  / 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  $AgNO_3$  **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 /  $AgNO_3$  **CE= 0** for the clip.*

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

*For **M1***

*Credit acidified (**OR**  $HNO_3$ ) 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 Br<sub>2</sub> **OR** bromine (water) **OR** bromine (in CCl<sub>4</sub> / 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 KMnO<sub>4</sub>/H<sub>2</sub>SO<sub>4</sub>**

- M1 acidified potassium manganate(VII) or KMnO<sub>4</sub>/H<sub>2</sub>SO<sub>4</sub>

**OR** KMnO<sub>4</sub>/ H<sup>+</sup> **OR** acidified KMnO<sub>4</sub>

- 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 H<sub>2</sub> SO<sub>4</sub>

- M2 no change, M3 brown

*Credit alkaline / neutral KMnO<sub>4</sub> 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 AgNO<sub>3</sub> or [Ag(NH<sub>3</sub>)<sub>2</sub>]<sup>+</sup> 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  $\text{CuSO}_4$  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**  $\text{KMnO}_4/\text{H}^+$  **OR** acidified  $\text{KMnO}_4$

M2 purple to colourless solution **OR** goes colourless

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

*Credit alkaline / neutral  $\text{KMnO}_4$  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  $\text{KMnO}_4$

**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  $\text{KMnO}_4$  for possible full marks but **M2** gives brown precipitate or solution goes green*

3

(b) **M1** (Shake with)  $\text{Br}_2$  **OR** bromine (water) **OR** bromine (in  $\text{CCl}_4$  / 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  $\text{KMnO}_4$

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

**M3** decolourised / goes colourless / loses its colour

**Use iodine**

**M1 iodine** or  $I_2$  / KI or iodine solution

**M2** no change

**M3** decolourised / goes colourless / loses its colour

**Use concentrated sulfuric acid**

**M1** concentrated  $H_2SO_4$

**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.*

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***

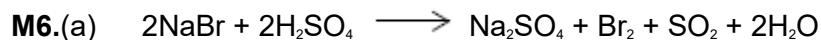
*Cream / off white precipitate with silver nitrate **M3***

1

[7]

**M5.D**

[1]



*Allow ionic equation*



1

$\text{Br}^-$  ions are bigger than  $\text{Cl}^-$  ions

1

Therefore  $\text{Br}^-$  ions more easily oxidised / lose an electron more easily (than  $\text{Cl}^-$  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*
- $\text{AgNO}_3 + \text{NaCl} \rightarrow \text{AgCl} + \text{NaNO}_3$
- $\text{AgNO}_3 + \text{NaBr} \rightarrow \text{AgBr} + \text{NaNO}_3$

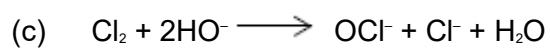
#### ***Stage 2: selective dissolving of AgCl***

- *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<sup>-</sup> is +1

Cl<sup>-</sup> is -1

*Both required for the mark*

1

**[11]**