EXAM PAPERS PRACTICE

Boost your performance and confidence with these topic-based exam questions

Practice questions created by actual examiners and assessment experts

Detailed mark scheme

Suitable for all boards

Designed to test your ability and thoroughly prepare you

Halogen 1

CHEMISTRY

Mark Scheme

AQA

AS & A LEVEL

Inorganic Chemistry

Mark schemes

1 (a) (i) $2Cl^- \longrightarrow Cl_2 + 2e^-$

Ignore state symbols

Credit loss of electrons from LHS

Credit multiples

Do not penalise absence of charge on electron

1

(ii) +7 ***OR*** 7 ***OR*** VII ***OR*** +VII

Allow Mn^{+7} and 7+

1

(iii) $MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$

Ignore state symbols

Credit loss of electrons from RHS

Credit multiples

Do not penalise absence of charge on electron

1

(b) (i) $Cl_2 + 2Br^- \longrightarrow 2Cl^- + Br_2$

OR

$\frac{1}{2}Cl_2 + Br^- \longrightarrow Cl^- + \frac{1}{2}Br_2$

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

(c) **M1** $2Cl_2 + 2H_2O \longrightarrow 4HCl + O_2$

$(4H^+ + 4Cl^-)$

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 Cl^{1-} 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]

2 (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*

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 $KMnO_4$ / 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 (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 <u>brown precipitate</u> or solution goes <u>green</u>*

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"

(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]**

3 (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]

4 (a) $2NaBr + 2H_2SO_4 \longrightarrow Na_2SO_4 + Br_2 + SO_2 + 2H_2O$

Allow ionic equation

$2Br^- + 2H_2SO_4 \longrightarrow Br_2 + SO_4^{2-} + SO_2 + 2H_2O$

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*
- *$AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$*
- *$AgNO_3 + NaBr \rightarrow AgBr + NaNO_3$*

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

- *Add excess of dilute ammonia to the mixture of precipitates*
- *the silver chloride precipitate dissolves*
- *$AgCl + 2NH_3 \rightarrow Ag(NH_3)_2^+ + Cl^-$*

***Stage 3**: separation and purification of AgBr*

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

6

(c) $Cl_2 + 2HO^- \longrightarrow OCl^- + Cl^- + H_2O$

1

OCl^- is +1

Cl^- is –1

Both required for the mark

1

[11]

5 D

[1]

6 D

[1]

7 (a) Hydrochloric acid = **C**

1

Barium chloride = **A**

1

(b) Barium sulfate is insoluble

1

$CuSO_4 + BaCl_2 \rightarrow BaSO_4 + CuCl_2$

Accept multiples.

Accept ionic equation.

Do not penalise lack of state symbols, but if used they must be correct.

1

(c) CO_2 / Carbon dioxide

1

(d) Reagent 1 silver nitrate (solution)

Ignore lack of reference to acidifying prior to addition of silver nitrate solution.

1

Observation 1 White precipitate

1

Reagent 2 (dilute) ammonia solution / aqueous ammonia

*Do not accept addition of **ammonia** only.*

1

Observation 2 (Colourless) solution

Allow ppt dissolves.

Do not allow 'goes colourless' or 'goes clear'.

Chlorine and no visible change or solution does not become orange scores M3 and M4.

1

(e) Gloves / wash hands after use

Ignore 'eye protection'.

Do not accept 'do not ingest the chemicals', 'wipe up spillages', 'use a fume cupboard', 'wear a lab coat' (list principle).

1

[10]

8 (a) (i) MnO_2 (+) 4

1

(ii) $MnO_2 + 4H^+ + 2e^- \longrightarrow Mn^{2+} + 2H_2O$

Or multiples

Ignore state symbols

Credit electrons subtracted from RHS

Ignore absence of charge on e

1

(iii) Iodide ion(s) is/are oxidised because they have lost electron(s)

Do not penalise reference to iodine; the mark is for electron loss

1

(b) (i) **M1** Cl_2 0

M2 HClO (+) 1

2

(ii) **M1** Equilibrium will shift/move to the right

OR L to R

OR to favour the forward reaction

OR to produce more HClO

M2 **Consequential on correct M1**

To oppose the loss of HClO

OR replaces the HClO (that has reacted)

for M2

NOT just "to oppose the change"

2

(c) (i) The answers can be in **either order**

M1 $2Br^- \longrightarrow Br_2 + 2e^-$

M2 $4H^+ + SO_4^{2-} + 2e^- \longrightarrow SO_2 + 2H_2O$

OR

$2H^+ + H_2SO_4 + 2e^- \longrightarrow SO_2 + 2H_2O$

NOT multiples

Ignore state symbols

Credit electrons subtracted from incorrect side

Ignore absence of charge on e

2

(ii) $KCl + H_2SO_4 \longrightarrow KHSO_4 + HCl$

OR

$2KCl + H_2SO_4 \longrightarrow K_2SO_4 + 2HCl$

Credit ionic equations

1

(iii) For M1 and M2, chloride ions are weaker reducing agents than bromide ions, because

M1 **Relative size of ions**

Chloride ions are smaller than bromide ions OR chloride ion electron(s) are closer to the nucleus OR chloride ion has fewer (electron) shells/levels OR chloride ion has less shielding (or converse for bromide ion)

M2 Strength of attraction for electron being lost

Outer shell/level electron(s) OR electron(s) lost from a chloride ion is more strongly held by the nucleus compared with that lost from a bromide ion (or converse for bromide ion)

If the forces are described as intermolecular or Van der Waals then CE = 0

Ignore general reference to Group 7 trend

For M1 accept reference to chlorine/bromine or reference to atoms of these but NOT "chloride/bromide atoms" or "chlorine/bromine molecules"

For M2 insist on reference to the correct ions

This is the expected answer, but award credit for a candidate who gives a correct explanation in terms of hydration enthalpy, electron affinity and atomisation enthalpy.

2

[12]

9 (a) Correct completion of table
(7.2 – 9.4 – 10.3 – 11.5 – 12.2 – 13.1)

Any error loses the mark.

1

Appropriate scales for axes

No penalty for missing labels but the graph must cover at least half of the available area.

1

All points plotted correctly

Allow ±1 small square.

1

Line of best fit acceptable

Must be a reasonably smooth curve but make allowance for freehand drawing passing within one small square of each point.

Do not penalise minor doubling of line.

1

(b) Maximum mass at (44.0 / 4) = 11.0 g
giving a max. pressure of 1.7 ± 0.1 MPa

Allow this pressure range only.

Check that candidate's answer matches graph.

1

(c) 7.2 g of NaCl in 250 cm^3 represents 28.8 g dm^{-3}

Allow 0.49 but not 0.5; otherwise do not penalise precision of answer

1

Molarity = 0.492 mol dm^{-3}

Conseq. to their graph value for 100 kPa to 2 or 3 sig.

1

(d) Measuring cylinder = (1 / 250) × 100 = 0.4%
Balance = (0.1 / 7.2) × 100 = 1.4%

Both values correct for the first mark.

Balance error conseq. on their 100 kPa mass value.

Ignore precision of answers.

1

Combined error 1.8%

*When error being calculated is **not** stated, allow **if** the calculations are in the same order as in the question (measuring cylinder, balance).*

If only combined error given then 1 mark only.

1

(e) (i) The points are good enough to be able to draw a smooth curve because the line passes through / close to all points.

Mark consequentially on candidate's graph

1

(ii) There are no anomalous points

Mark consequentially on candidate's graph

1

(f) The experiment only seeks an approximate figure for the maximum pressure

Allow words to that effect.

1

(g) (i) Toxic (to marine life)

Allow phrasing which implies a detrimental effect on marine ecology.

1

(ii) Mixing the effluent with (sea) water to dilute it

Penalise any method which removes the salt or which implies storage.

1

(h) $2Br^- + Cl_2 \rightarrow 2Cl^- + Br_2$

Allow NaBr or KBr

1

(i) The cost of removing water / heating would be too high

Discount answers based on toxicity or speed of reaction.

Allow answers based on cost of using sulfuric acid.

1

(j) (i) Carbon

Allow C, soot, graphite, coal.

1

(ii) Formed by the decomposition of organic material / living organisms in the sea water

Allow 'erosion of coal beds'.

1

(iii) Dissolve the solid formed in water

Do not allow melting of the solid.

1

Filter off the insoluble particles

1

(k) $Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$

Allow $Ca(OH)_2 + 2H^+ \rightarrow Ca^{2+} + 2H_2O$

Allow multiples.

1

(l) In agriculture / to raise the pH of soil / (Lime-based) mortars in construction

Allow words to that effect.

1

[22]

10 (a) **M1** Cl_2 (provides the pale green colour)

M1 requires the formula

M2 NaOH reacts with the acid(s)/the HCl/the HClO/H^+

Ignore "reacts with the products"

Ignore "reacts with chloride ion"

Ignore "reacts with chlorine"

M3 requires a correct answer in M2

Equilibrium shifts (from left) to right ***OR*** wtte

3

(b) **M1** A reducing agent is an electron donor OR (readily) loses/gives away electrons

Penalise M1 if "electron pair donor"

M2 $Cl_2 + 2e^- \rightarrow 2Cl^-$

For M3 and M4, iodide ions are stronger reducing agents than chloride ions, because

Ignore state symbols in M2 Accept no charge on the electron
Credit the electrons being lost on the RHS

M3 Relative size of ions/atomic radius/ionic radius
Iodide ions are larger/have more (electron) shells/levels than chloride ions (or converse for chloride ion) OR electron(s) to be lost/outer shell/level is further from the nucleus (or converse for chloride ion) OR greater/more shielding

For M3 insist on "iodide ions"

M4 Strength of attraction for electron(s) being lost
Electron(s) lost from an iodide ion is less strongly held by the nucleus compared with that lost from a chloride ion

M3 and M4 must be comparative and should refer to electrons.

(assume argument refers to iodide ions but accept converse argument for chloride ions)

4

(c) **M1** $2Cl_2 + 2H_2O \rightarrow 4HCl + O_2$

Or multiples

M2 silver chloride ONLY

M2 requires a name

M3 The solid/precipitate would dissolve
OR is soluble
OR (It) forms a (colourless) solution

Mark M3 independently
Ignore "disappears"

3

(d) Electrophilic addition

1

Mechanism:

M2 Penalise partial charges if wrong way around, otherwise ignore

*Max 3 marks **for the mechanism** for wrong reactant and/or "sticks" (wrong reactant could be HBr or Br_2 or incorrect alkene)*

M1 must show an arrow from the double bond towards one of the Cl atoms on a Cl–Cl molecule.

M2 must show the breaking of the Cl–Cl bond.

M3 is for the structure of the carbocation with Cl substituent.

M4 must show an arrow from the lone pair of electrons on a negatively charged chloride ion towards the positively charged carbon atom.

4

[15]

11 (a) NaBr ONLY

Penalise incorrect case or additional formulae.
Ignore names

1

(b) NaF ONLY

Penalise incorrect case or additional formulae.
Ignore names

1

(c) ONLY one from either
NaF

OR

NaCl

Penalise incorrect case or additional formulae.
Ignore names

1

(d) NaI ONLY

Penalise incorrect case or additional formulae.
Ignore names

1

[4]

12 (a) (i) **M1 Initiation**

$Cl_2 \longrightarrow 2Cl\bullet$

M2 First propagation

$Cl\bullet + CH_3CH_3 \longrightarrow \bullet CH_2CH_3 + HCl$

C_2H_6

M3 Second propagation

$Cl_2 + \bullet CH_2CH_3 \longrightarrow CH_3CH_2Cl + Cl\bullet$

C_2H_5Cl

M4 Termination (must make C_4H_{10})

$2 \bullet CH_2CH_3 \longrightarrow C_4H_{10}$ or $CH_3CH_2CH_2CH_3$

Penalise absence of dot once only.
Penalise + or – charges every time
Penalise incorrect position of dot on ethyl radical once only.
Penalise $C_2H_5\bullet$ once only
Accept $CH_3CH_2\bullet$ with the radical dot above/below/to the side of the CH_2
Mark independently

4

(ii) **M1** ultra-violet/uv/sun light
OR (very) high temperature OR 500 °C ≥ T ≤1000 °C

M2 (free-)radical substitution
Ignore "heat" for M1
Both words needed for M2
For M2, ignore the word "mechanism"

2

(b) (i) $Cl_2 + H_2O \longrightarrow HClO + HCl$

OR

$Cl_2 + H_2O \longrightarrow 2H^+ + ClO^- + Cl^-$

Accept HOCl or ClOH
Accept other ionic or mixed representations
Ignore state symbols

1

(ii) **M1** Any one from
- in swimming pools
- in drinking water
- to sterilise/disinfect/sanitise water
- in water treatment

Ignore the manufacture of bleach
Ignore "to clean water"
Ignore "water purification"

M2 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

Mark independently but M1 can score from (M2) explanation

2

(iii) Sodium chlorate(I) or sodium hypochlorite

Must be named
Ignore (in)correct formulae
Insist on the (I) in the name

1

(c) (i) $Cl_2 + 2Br^- \longrightarrow Br_2 + 2Cl^-$

Or half this equation
Ignore state symbols

1

(ii) **M1 The relative size (of the molecules/atoms)**
Bromine is larger than chlorine OR has more electrons/electron shells
OR It is larger/It has a larger atomic radius/it is a larger molecule/atom

M2 How size of the intermolecular force affects energy needed
The forces between bromine/Br_2 molecules are stronger (than the forces between chlorine/Cl_2 molecules leading to more energy needed to separate the molecules) (or converse)
OR bromine/Br_2 has stronger/more (VdW) intermolecular forces.
(or converse)

For M1 ignore whether it refers to molecules or atoms.

CE = 0 for reference to (halide) ions

Ignore molecular mass

QoL *for clear reference to the difference in size of the force between molecules*

Penalise M2 if covalent bonds are broken

2

[13]

13 (a) (ligand) substitution

Allow 'ligand exchange'.

1

(b) To displace the equilibrium to the right

To ensure reaction goes to completion.

1

To improve the yield

Allow 'to replace all chlorines'.

1

(c) (i) $K_2PtCl_4 + 4KI \rightarrow K_2PtI_4 + 4KCl$

Allow correct ionic equations $PtCl_4^{2-} + 4I^- \rightarrow PtI_4^{2-} + 4Cl^-$

Allow multiples and fractions.

1

(ii) $= (780.9) \times 100 / (415.3 + 664)$

Working must be clearly shown.

Allow one mark for correct relationship even if M_r values are incorrect eg using values from ionic equation.

1

= 72.4

Allow 72%

1

(d) (i) $Ag^+ + I^- \rightarrow AgI$

Ignore state symbols even if incorrect.

This equation only.

1

(ii) Stops the reverse reaction / equilibrium displaced to the right

1

(e) Number of steps in the process

Allow 'equilibrium may lie on the reactant side' / side reactions / isomer formation.

1

Losses at each stage of the synthesis

Equilibrium losses or practical losses or yield not 100% for each step.

1

(f) Minimum amount of hot solvent

Accept 'small' for minimum.

Accept water.

1

Cool / crystallise

1

Filter

1

(g) (i) Small amounts are more likely to kill cancer cells rather than the patient

1

(ii) Wear gloves / wash hands after use

Ignore masks.

Apply the list principle if more than one answer.

1

[15]

14 (a) (i) Green

Ignore shades of green.

1

(ii) Excess acidified potassium dichromate(VI)

1

Reflux (for some time)

1

In the diagram credit should be given for

- a vertical condenser

  Lose M3 and M4 for a distillation apparatus.

1

- an apparatus which would clearly work

  Do not allow this mark for a flask drawn on its own.

  Penalise diagrams where the apparatus is sealed.

1

(iii) Distillation

1

Immediately (the reagents are mixed)

1

(b) Keep away from naked flames

Allow heat with water-bath or heating mantle.

If a list is given ignore eye protection, otherwise lose this mark.

1

(c) (i) Tollens' or Fehling's reagents

*Incorrect reagent(s) loses **both** marks.*

Accept mis-spellings if meaning is clear.

1

Silver mirror / red ppt. formed

Accept 'blue to red' but not 'red' alone.

1

(ii) Sodium carbonate (solution) / Group II metal

Allow indicator solutions with appropriate colours.

Accept any named carbonate or hydrogen carbonate.

1

Effervescence / evolves a gas

Accept 'fizzes'.

1

(d) Propanoic acid

If this mark is lost allow one mark if there is reference to stronger intermolecular forces in the named compound.

Lose M1 and M3.

1

Contains hydrogen bonding

1

Some comparison with other compounds explaining that the intermolecular forces are stronger in propanoic acid

1

[15]

15 (a) To ensure that other (an)ions do not interfere

Accept 'to prevent other salts precipitating'.

Accept 'to remove carbonate / hydroxide (ions)'.

1

(b) Concentrated (ammonia)

'Precipitate partially soluble in dilute ammonia' scores both marks.

1

Precipitate soluble / dissolves

1

[3]

16 (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

(b) $Ba^{2+} + SO_4^{2-} \longrightarrow BaSO_4$

1

$[Fe(H_2O)_6]^{3+} + 3OH^- \longrightarrow Fe(H_2O)_3(OH)_3 + 3H_2O$

1

$2[Fe(H_2O)_6]^{3+} + 3CO_3^{2-} \longrightarrow 2Fe(H_2O)_3(OH)_3 + 3H_2O + 3CO_2$

1

$[Fe(H_2O)_6]^{3+} + 4Cl^- \longrightarrow [FeCl_4]^- + 6H_2O$

1

[10]

17 (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 $Cl_2 + 2e^- \longrightarrow 2Cl^-$

Credit 1 or 2 electrons but not lone pair.
The idea of 'reduction' alone is not enough.

1

(b) (i) $6KI + 7H_2SO_4 \longrightarrow 6KHSO_4 + 3I_2 + S + 4H_2O$

1

(ii) $2I^- \longrightarrow I_2 + 2e^-$

OR

$8I^- \longrightarrow 4I_2 + 8e^-$

Ignore charge on the electron unless incorrect.
Or multiples.
Credit the electrons being subtracted on the LHS.
Ignore state symbols.

1

(iii) $H_2SO_4 + 8H^+ + 8e^- \longrightarrow H_2S + 4H_2O$

OR

$SO_4^{2-} + 10H^+ + 8e^- \longrightarrow H_2S + 4H_2O$

Ignore charge on the electron unless incorrect.
Or multiples.
Credit the electrons being subtracted on the RHS.
Ignore state symbols.

1

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

(iii) $Cl_2 + H_2O \longrightarrow HClO + HCl$

OR

$Cl_2 + H_2O \longrightarrow 2H^+ + ClO^- + Cl^-$

OR

$2Cl_2 + 2H_2O \longrightarrow 4HCl + O_2$

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.

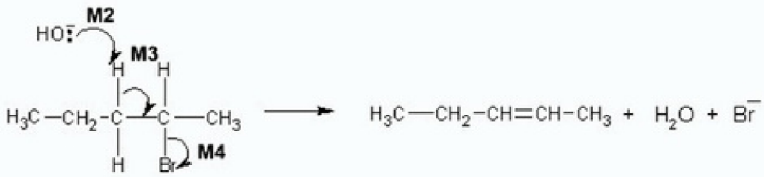
NaClO (OR NaOCl) **and** NaCl

Give credit for answers in equations unless contradicted.

1

[14]

18 (a) (i) **M1** Elimination



M2 must show an arrow from the lone pair on the oxygen of a negatively charged hydroxide ion to a correct H atom

M3 must show an arrow from a C-H bond adjacent to the C-Br bond towards the appropriate C-C bond.
Only award if a reasonable attempt has been made at the attack on the H atom of the appropriate adjacent C-H

M4 is independent provided it is from their original molecule

Award full marks for an E1 mechanism in which **M3** is on the correct carbocation.

N.B. These are double-headed arrows

For M1, accept "Base elimination" but no other prefix.

*Penalise **M2** if covalent KOH*

*Penalise **M4** for formal charge on C of C-Br or incorrect partial charges on C-Br*

Ignore other partial charges

Penalise once only in any part of the mechanism for a line and two dots to show a bond.

*Max any 2 of 3 marks **for the mechanism** for wrong reactant (or wrong product if shown).*

Accept the correct use of "sticks" for the molecule except for the C-H being attacked

4

(ii) **Structure for pent-1-ene**

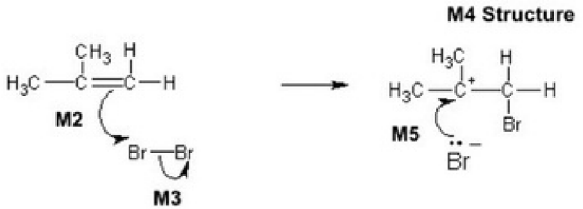
$CH_3CH_2CH_2CH{=}CH_2$

Penalise C_3H_7

Accept correct "sticks"

1

(b) **M1 Electrophilic addition**



M2 must show an arrow from the double bond towards the Br atom of the Br-Br molecule

M3 must show the breaking of the Br-Br bond.

M4 is for the structure of the tertiary carbocation with Br on the correct carbon atom.

M5 must show an arrow from the lone pair of electrons on the negatively charged bromide ion towards the positively charged carbon atom.

N.B. These are double-headed arrows

For M1, both words required.

For the mechanism

***M2** Ignore partial negative charge on the double bond.*

***M3** Penalise partial charges on Br-Br bond if wrong way and penalise formal charges*

Penalise once only in any part of the mechanism for a line and two dots to show a bond

*Max any 3 of 4 marks **for the mechanism** for*

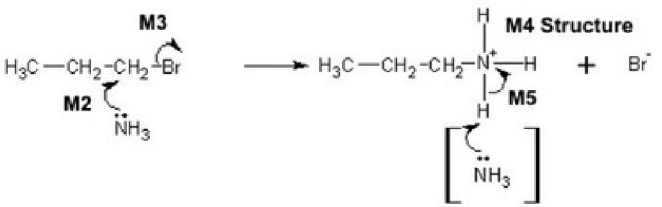
wrong organic reactant or wrong organic product (if shown) or primary carbocation.

*If HBr is used, max 2 marks **for their mechanism***

Accept the correct use of "sticks"

5

(c) **M1** **Nucleophilic substitution**



M2 must show an arrow from the lone pair of electrons on the nitrogen atom of an ammonia molecule to the C atom.

M3 must show the movement of a pair of electrons from the C-Br bond to the Br atom. **M3** is independent provided it is from their original molecule

M4 is for the structure of the alkylammonium ion, which could be a condensed formula. A positive charge must be shown on/or close to, the N atom.

M5 is for an arrow from the N-H bond to the N atom.

Award full marks for an S_N1 mechanism in which M2 is the attack of the ammonia on the intermediate carbocation.

N.B. These are double-headed arrows

*For **M1**, both words required.*

*Penalise **M2** if NH_3 is negatively charged.*

*Penalise **M3** for formal charge on C or incorrect partial charges*

The second mole of ammonia is not essential for M5; therefore ignore any species here.

Penalise once only for a line and two dots to show a bond.

*Max any 3 of 4 marks **for the mechanism** for wrong organic reactant (or wrong organic product if shown)*

Accept the correct use of "sticks"

5

[15]

19 (a) (i) **M1** (yellow precipitate is) silver iodide OR AgI (which may be awarded from the equation)

M2 $Ag^+ + I^- \longrightarrow AgI$ (Also scores M1 unless contradicted)

M3 sodium chloride OR NaCl

For M2

Accept multiples

Ignore state symbols

Allow crossed out nitrate ions, but penalise if not crossed out

3

(ii) The silver nitrate is acidified to

- react with / remove ions that would interfere with the test
- prevent the formation of other silver precipitates / insoluble silver compounds that would interfere with the test
- remove (other) ions that react with the silver nitrate
- react with / remove carbonate / hydroxide / sulfite (ions)

Ignore reference to "false positive"

1

(iii) **M1 and M2 in either order**

M1 Fluoride (ion) OR F

M2 • Silver fluoride / AgF is soluble / dissolves (in water)

• no precipitate would form / no visible /observable change

Do not penalise the spelling "fluoride",

Penalise "fluride" once only

Mark M1 and M2 independently

2

(b) **M1** $Ba^{2+} + SO_4^{2-} \longrightarrow BaSO_4$

(or the ions together)

M2 white precipitate / white solid / white suspension

M3 Barium meal or (internal) X-ray or to block X-rays

M4 $BaSO_4$ / barium sulfate is insoluble (and therefore not toxic)

For M1, ignore state symbols

Allow crossed out sodium ions, but penalise if not crossed out

For M2, ignore "milky"

If $BaSO_3$ OR BaS used in M1 and M4, penalise once only

For M3 Ignore radio-tracing

For M4 NOT barium ions

NOT barium

NOT barium meal

NOT "It" unless clearly $BaSO_4$

4

(c) **M1** **2**(12.00000) + **4**(1.00794) = 28.03176

M2 Ethene and CO or "they" have an imprecise M_r of 28.0 / 28

OR

Ethene and CO or "they" have the same M_r to one d.p.

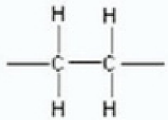
OR

These may be shown by two clear, simple sums identifying both compounds

M3 $C_2H_4 + 2O_2 \longrightarrow 2CO + 2H_2O$

$(H_2C{=}CH_2)$

M4 Displayed formula



M5 Type of polymer = Addition (polymer)

M1 must show working using 5 d.p.for hydrogen

Penalise "similar" or "close to", if this refers to the imprecise value in M2, since this does not mean "the same"

For M3, accept $CH_2{=}CH_2$ OR CH_2CH_2

For M4, all bonds must be drawn out including those on either side of the unit.

Penalise "sticks"

*Ignore brackets around **correct** repeating unit but penalise "n"*

Penalise "additional"

5

[15]

20 (a) (i) **M1** **0**

M2 **(+) 5**

Accept Roman V for M2

2

(ii) $I_2 + 10HNO_3 \longrightarrow 2HIO_3 + 10NO_2 + 4H_2O$

Accept multiples

1

(b) **M1** $IO_3^- + 6H^+ + 5I^- \longrightarrow 3I_2 + 3H_2O$

For M1, ignore state symbols

Credit multiples

Accept $2\frac{1}{2}I_2 + \frac{1}{2}I_2$ as alternative to $3I_2$

Electrons must be cancelled

M2 $NaIO_3$ ***OR*** IO_3^- ***OR*** iodate ions ***OR*** iodate(V) ions etc.

For M2 Do not penalise an incorrect name for the correct oxidising agent that is written in addition to the formula.

Accept "the iodine in iodate ions" but NOT "iodine" alone

Accept "the iodine / I in iodate ions" but NOT "iodine" alone

2

(c) (i) Iodine ***OR*** I_2

Insist on correct name or formula

1

(ii) $H_2SO_4 + 6H^+ + 6e^- \longrightarrow S + 4H_2O$

Ignore state symbols

$SO_4^{2-} + 8H+ + 6e^- \longrightarrow S + 4H_2O$

Credit multiples

Do not penalise absence of charge on the electron

1

(d) hydrogen sulfide

OR H_2S

OR hydrogen sulphide

1

(e) (i) $Ag^+ + I^- \longrightarrow AgI$ ONLY

Ignore state symbols

No multiples

1

(ii) The (yellow) precipitate / solid / it does not dissolve / is insoluble

ignore "nothing (happens)"

OR turns to a white solid

ignore "no observation"

OR stays the same

OR no (visible/ observable) change

OR no effect / no reaction

1

(iii) The silver nitrate is acidified to

- react with / remove (an)ions that would interfere with the test

  Ignore reference to "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

- react with / remove carbonate / hydroxide / sulfite (ions)

  If only the formula of the ion is given, it must be correct

1

(f) (i) An electron donor

Penalise "electron pair donor"

OR (readily) donates / loses / releases / gives (away) electron(s)

Penalise "loss of electrons" alone

Accept "electron donator"

1

(ii) $Cl_2 + 2e^- \longrightarrow 2Cl^-$

Ignore state symbols

Do not penalise absence of charge on electron

Credit $Cl_2 \longrightarrow 2Cl^- - 2e^-$

Credit multiples

1

(iii) For M1 and M2, iodide ions are stronger reducing agents than chloride ions, because

Ignore general statements about Group VII trends or about halogen molecules or atoms. Answers must be specific

M1 Relative size of ions

CE=0 for the clip if "iodine ions / chlorine ions" ***QoL***

Iodide ions / they are larger /have more electron levels(shells) (than chloride ions) / larger atomic / ionic radius

CE=0 for the clip if "iodide ions are bigger molecules / atoms" ***QoL***

OR electron to be lost/outer shell/level (of the iodide ion) is further the nucleus

OR iodide ion(s) / they have greater / more shielding

Insist on iodide ions in M1 and M2 or the use of it / they / them, in the correct context (or chloride ions in the converse argument)

OR converse for chloride ion

M2 Strength of attraction for electron(s)

Must be comparative in both M1 and M2

The electron(s) lost /outer shell/level electron from (an) iodide ion(s) less strongly held by the nucleus compared with that lost from a chloride ion

OR converse for a chloride ion

2

[15]

21 (a) Iodine has more electrons / iodine is bigger (atom or molecule) / iodine has bigger M_r / bigger surface area

1

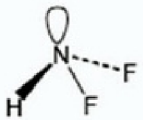
Stronger / more van der Waals forces / vdw / London / temporarily induced dipole / dispersion forces between molecules

1

Stronger VdW intermolecular forces = M2

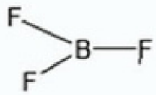
If stated VdW between atoms lose M2

(b) (i)



Mark is for 3 bp and 1 lp attached to N (irrespective of shape)

1



Mark is for 3 bp and 0 lp attached to B (irrespective of shape)

1

NHF_2 shape - pyramidal / trigonal pyramid

Accept tetrahedral / triangular pyramid

1

BF_3 shape - trigonal planar

Not triangular or triangular planar

1

(ii) 107°

Allow 106-108°

1

(c) Hydrogen bonds

Allow H-Bonds

Not just Hydrogen

Apply list principle eg Hydrogen bonding and dipole-dipole = 0

1

(d) Coordinate / dative covalent / dative

If covalent mark on

If ionic / metallic CE = 0

1

Lone pair / both electrons/ 2 electrons on $N(HF_2)$ donated (to BF_3)

Direction of donation needed here

1

[10]

22 (a) $Ca(OH)_2$ OR $Mg(OH)_2$

Ignore name

Could be ionic

1

(b) NaF or sodium fluoride

OR

NaCl or sodium chloride

Either formula or name can score

Do not penalise the spelling "fluoride"

When both formula and name are written,

- *penalise contradictions*
- *if the attempt at the correct **formula** is incorrect, ignore it and credit **correct name** for the mark unless contradictory*
- *if the attempt at the correct name is incorrect, ignore it and credit **correct formula** for the mark unless contradictory*

1

(c) NaClO OR NaOCl

Ignore name (even when incorrect)

The correct formula must be clearly identified if an equation is written

1

(d) **Br_2** (ONLY)

Only the correct formula scores;

penalise lower case "b", penalise upper case "R", penalise superscript

Ignore name

The correct formula must be clearly identified if an equation is written

1

(e) **M1** S OR S_8 OR S_2

M2 I_2 (ONLY)

Ignore names

penalise lower case "i" for iodine,

penalise superscripted numbers

Mark independently

The correct formula must be clearly identified in each case if an equation is written

2

(f) (i) $CH_3CH_2CH=CH_2$

Structure of but-1-ene. Ignore name

Credit "sticks" for C-H bonds

1

(ii) $CH_3CH_2CH_2CH_2OH$

Structure of butan-1-ol. Ignore name

Credit "sticks" for C-H bonds

1

(iii) $CH_3CH_2CH_3$

Structure of propane. Ignore name

Ignore calculations and molecular formula

Credit "sticks" for C-H bonds

Ignore the molecular ion

1

(iv) CH_3CH_2Br OR $C_2H_5B_r$

Structure of bromoethane.

Ignore name and structure of nitrile

Credit "sticks" for C-H bonds

1

[10]

23 (a) (i) $SrCl_2(aq) + Na_2SO_4(aq) \rightarrow SrSO_4(s) + 2NaCl(aq)$

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]

24 (a) (i) 1.08×10^{-2}

Do not penalise precision but must be to at least 2 significant figures.

Do not accept 1×10^{-2}

1

(ii) $5.4(0) \times 10^{-3}$

Allow (i) / 2

Do not penalise precision but must be to at least 2 significant figures.

1

(iii) 266.6

Lose this mark if answer not given to 1 decimal place.

1

(iv) mass = $5.4(0) \times 10^{-3} \times 266.6 = 1.44$ g **M1**

Allow (ii) × (iii).

1

percentage = $1.44 \times 100 / 2.25 = 64.0$ **M2**

*Allow consequential answer from **M1***

Lose this mark if answer not given to 3 significant figures.

*Correct answer with no working scores **M2** only.*

1

(v) 1 Would give an incorrect / too large mass (of silver chloride)

Do not allow 'to get an accurate result' without qualification.

1

2 To remove soluble impurities / excess silver nitrate (solution) / strontium nitrate (solution)

Do not allow 'to remove impurities'.

Do not allow 'to remove excess strontium chloride solution'.

1

(b) (i) $Mg^{2+}(aq) + 2OH^-(aq) \rightarrow Mg(OH)_2(s)$

Allow $Mg^{2+}(aq) + 2OH^-(aq) \rightarrow Mg^{2+}(OH^-)_2(s)$

Allow multiples, including fractions.

Lose mark if state symbols are missing or incorrect.

Lose mark if incorrect charge on an ion.

1

(ii) Does not produce CO_2 / gas which distends stomach / does not produce wind / does not increase pressure in stomach

Allow 'prevents flatulence' and 'prevents burping'.

Do not allow 'gas' without qualification.

1

(c) $(CH_3COO)_2Ca \rightarrow CH_3COCH_3 + CaCO_3$

Allow multiples.

Allow propanone as C_3H_6O

Allow $(CH_3COO^-)_2Ca^{2+} \rightarrow CH_3COCH_3 + Ca^{2+}CO_3^{2-}$

1

(d) Ca (salt) - no visible change with sodium chromate(VI) **M1**

Allow 'yellow solution formed' or 'no ppt. forms'.

*Allow **M1** and **M2** in any order.*

1

Sr and Ba (salts) give (yellow) precipitate with sodium chromate(VI) **M2**

Lose this mark if precipitate has an incorrect colour.

1

Sr precipitate (chromate(VI)) dissolves in ethanoic acid / Ba precipitate (chromate(VI)) does not dissolve in ethanoic acid **M3**

*If ethanoic acid is added first, allow access to **M1** and **M3**.*

1

(e) C 42.09 / 12, H 2.92 / 1, N 8.18 / 14, O 37.42 / 16 and S 9.39 / 32.1

Accept any other correct method of working.

If relative atomic mass has been divided by the percentage composition is used then CE = 0 / 2

1

$C_{12}H_{10}N_2O_8S$

Correct answer with no working scores 1 mark only.

1

[15]

25 (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 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_2 ***OR*** bromine (water) ***OR*** bromine (in CCl_4 / 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 $KMnO_4/H_2SO_4$

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

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

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 $H_2 SO_4$
M2 no change, M3 brown

*Credit alkaline / neutral $KMnO_4$ 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 $AgNO_3$ or $[Ag(NH_3)_2]^+$ 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 $Cu^{2+}(aq)$ 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 $K_2Cr_2O_7/H_2SO_4$
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 (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 $KMnO_4/H_2SO_4$
M1 acidified potassium manganate(VII) or $KMnO_4/H_2SO_4$
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]

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

Ignore state symbols

*Credit **M1** for "iodine solution"*

M2 $Cl_2 + 2I^- \longrightarrow 2Cl^- + I_2$

OR

$\frac{1}{2} Cl_2 + I^- \longrightarrow Cl^- + \frac{1}{2} I_2$

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) <u>silver chloride</u>

***M1** <u>must be named</u> and for <u>this mark</u> ignore incorrect formula*

M2 $Ag^+ + Cl^- \longrightarrow AgCl$

*For **M2** ignore state symbols*

Penalise multiples

M3 (white) precipitate / <u>it dissolves</u>

OR <u>colourless solution</u>

Ignore references to "clear" alone

3

(b) (i) **M1** $H_2SO_4 + 2Cl^- \longrightarrow 2HCl + SO_4^{2-}$

*For **M1** ignore state symbols*

OR $H_2SO_4 + Cl^- \longrightarrow HCl + HSO_4^-$

Penalise multiples for equations and apply the list principle

OR $H^+ + Cl^- \longrightarrow HCl$

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 $2I^- \longrightarrow I_2 + 2e^-$

OR

$8I^- \longrightarrow 4I_2 + 8e -$

Do not penalise absence of charge on the electron

Credit electrons shown correctly on the other side of each equation

M2 $H_2SO_4 + 8H^+ + 8e^- \longrightarrow H_2S + 4H_2O$

OR

$SO_4^{2-} + 10H+ + 8e^- \longrightarrow H_2S + 4H_2O$

Additional equations should not contradict

M3 oxidising agent / oxidises the iodide (ions)

OR

electron acceptor

M4 sulfur ***OR*** S ***OR*** S_2 ***OR*** S_8 ***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]

27 Test — silver nitrate (solution) **(M1)**

Allow an alternative soluble silver salt eg fluoride, sulfate.

Do not allow 'silver ions' but can access second mark.

Incorrect formula loses this mark but can access second mark.

Do not allow 'silver' or an insoluble silver salt and ***cannot*** *access second mark.*

Ignore references to acidification of the silver nitrate.

If an acid is specified it should be nitric acid, but allow sulfuric acid in this case as there are no metal ions present.

If hydrochloric acid is used, CE = 0 / 2.

Do not allow 'add water'.

1

Observation — white precipitate **(M2)**

Ignore 'cloudy'.

Do not allow 'white fumes' or 'effervescence'.

Do not allow this mark if test reagent is incorrect or missing.

Allow named indicator paper or named indicator solution for ***M1****.*

Allow correct colour change for ***M2****.*

1

[2]

28 **M1 and M2 (either order)**

Any two from

- purple <u>vapour / gas</u>
- (white solid goes to) black or black / grey or black / purple <u>solid</u>
- bad <u>egg smell</u> or words to this effect

Ignore misty white fumes
Ignore yellow solid
Ignore purple solid
Ignore "goes (dark) brown"

M3

*Or multiples for possible equation in **M3***

The <u>iodide ion(s) / they lose (an) electron(s)</u>

OR

$2I^- \longrightarrow I_2 + 2e^-$

M4

Accept "changes by − 8"

Oxidation state of S changes from **<u>+6 to −2</u>** or **<u>changes by 8</u>**

M5

$H_2SO_4 + 8H^+ + 8e^- \longrightarrow H_2S + 4H_2O$

OR

$SO_4^{2-} + 10H^+ + 8e^- \longrightarrow H_2S + 4H_2O$

[5]

29 (a) M1 $Cl_2 + 2Br^- \longrightarrow 2Cl^- + Br_2$

Accept a correct equation using ½ Cl_2 but no other multiples

M2 solution goes <u>orange / yellow</u> (from colourless)

Ignore reference to brown colour
Penalise incorrect observations eg fumes, precipitates

2

(b) M1 $Cl_2 + 2NaOH \longrightarrow NaClO + NaCl + H_2O$

(NaOCl)

Or a correct ionic equation

Ignore reference to "swimming pools" and to "disinfectant"

M2 bleach or kills bacteria / bacteriacide / micro-organisms / microbes

M3 sodium chlorate(I) ONLY

3

(c) M $Cl_2 + H_2O \rightleftharpoons HClO + HCl$

(HOCl)

*Equilibrium symbol **required** in **M1***

Accept ionic RHS

M2

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

2

(d) M1 Silver nitrate OR $AgNO_3$ (with or without nitric acid)

*For **M1***

If only the formula is written then it must be correct

If both the formula and the name are written then ignore incorrect attempt at the formula, but penalise an incorrect name

M2 (depends on M1)

white precipitate / white solid

*If the reagent is incomplete eg Ag^+ ions, penalise **M1** and mark on*

M3 $Ag^+ + Cl^- \longrightarrow AgCl$

*Penalise both **M1** and **M2** for alkaline $AgNO_3$ **OR** for the use of HCl to acidify the silver nitrate **OR** for Tollens' reagent*

3

[10]

30 (a) (i) $\frac{1}{2}Cl_2 + I^- \longrightarrow \frac{1}{2} I_2 + Cl^-$

Only *these two equations.*

OR

$Cl_2 + 2I^- \longrightarrow I_2 + 2Cl^-$

1

(ii) (Solution turns from colourless to) brown / red-brown solution

Allow grey / black solid.

Ignore "purple".

1

(b) $2Cl_2 + 2H_2O \longrightarrow 4HCl + O_2$

$(4H^+ + 4Cl^-)$

Credit multiples.

1

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

Chlorine is smaller than bromine OR has fewer electrons / electron shells ***OR*** It is smaller / It has a smaller atomic radius / it is a smaller molecule / or has smaller M_r

(or converse for bromine)

Ignore general Group 7 statements.

*For **M1** ignore whether it refers to molecules or atoms.*

M2 **How size of the intermolecular force affects energy needed**

The forces between chlorine / Cl_2 molecules are weaker (than the forces between bromine / Br_2 molecules leading to less energy needed to separate the molecules)

(or converse for bromine)

OR chlorine / Cl_2 has weaker / less / fewer forces between molecules ***OR*** chlorine / Cl_2 has weaker / less / fewer intermolecular forces

(or converse for bromine)

CE=0 *for reference to (halide) ions.*

QoL for clear reference to the difference in size of the force between molecules.

*Penalise **M2** if (covalent) bonds are broken.*

2

[5]