**M1.**(a) $Cl_2 + H_2O \rightleftharpoons HOCl + HCl$

*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]**

**M2.**(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]**

**M3.**(a) M1 $Cl_2 + \mathbf{2}Br^- \longrightarrow \mathbf{2}Cl^- + Br_2$

*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 <u>sodium chlorate(I)</u> 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]**

**M4.**(a) (i) $\frac{1}{2}Cl_2 + I^- \longrightarrow \frac{1}{2} I_2 + Cl^-$

***Only** these two equations.*

OR

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

**1**

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

*Allow grey / black solid.*

*Ignore "purple".*

**1**

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

$(\mathbf{4}H^+ + \mathbf{4}Cl^-)$

*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]**

**M5.**(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 $Cl_2 + \mathbf{2}e^- \longrightarrow \mathbf{2}Cl^-$

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

**1**

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

**1**

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

**OR**

$8I^- \longrightarrow 4\mathbf{I_2} + 8e^-$

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

**1**

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

**OR**

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

*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 <u>(an)ions that would interfere</u> with the test

  *Credit a correct reference to <u>ions</u> that give a 'false positive'.*

- prevent the formation of other <u>silver precipitates /</u> <u>insoluble silver compounds</u> 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) <u>ions that react with the silver nitrate</u>

  *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 <u>form a</u> (white) <u>precipitate /</u> (white) <u>solid</u> (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**

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

**OR**

$\mathbf{2}Cl_2 + \mathbf{2}H_2O \longrightarrow \mathbf{4}HCl + O_2$

*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]**