Q1 Which is **not** a redox reaction?

A $Br_2 + SO_2 + 2\ H_2O \rightarrow 2\ Br^- + SO_4^{2-} + 4\ H^+$ ⬭

B $Cr_2O_7^{2-} + H_2O \rightarrow 2\ CrO_4^{2-} + 2\ H^+$ ⬭

C $Cu_2O + H_2SO_4 \rightarrow CuSO_4 + Cu + H_2O$ ⬭

D $SnCl_2 + HgCl_2 \rightarrow Hg + SnCl_4$ ⬭

Q2

Bromine is an oxidising agent.

(a) State, in terms of electrons, the meaning of oxidising agent.

_____

_____

(1)

In aqueous solution, bromine oxidises SO_2 to SO_4^{2-} ions.

(b) Write a half-equation for the oxidation of aqueous SO_2 to SO_4^{2-} ions.

_____

(1)

(c) Write an equation for the reaction of bromine with aqueous SO_2

Explain, using oxidation states, how bromine oxidises SO_2 to SO_4^{2-} ions.

Equation

_____

Equation _____

_____

_____

_____

(3)

(d) A few drops of aqueous bromine are added to a test tube that contains some sodium iodide solution.

State the colour change observed in the test tube.

Write an equation for this reaction.

Colour change _____

_____

Equation

_____

(2)

(Total 7 marks)

Q3

Chlorine reacts with hot concentrated sodium hydroxide.

$3\ Cl_2 + 6\ NaOH \longrightarrow 5\ NaCl + NaClO_3 + 3\ H_2O$

Identify the element that is oxidised in this reaction.

Explain your answer using oxidation states.

Element oxidised _____

_____

Explanation _____

(2)

Q4

Under some conditions, nitrate(V) ions (NO_3^-) can oxidise Mn^{2+} ions to MnO_2 and the nitrate(V) ions are reduced.

An experiment is used to find the oxidation state of nitrogen at the end of the reaction.

In this experiment, 24.0 cm^3 of 0.150 mol dm^{-3} aqueous solution of Mn^{2+} ions react with exactly 15.0 cm^3 of 0.0960 mol dm^{-3} aqueous solution of NO_3– ions.

Write a half-equation for the oxidation of Mn^{2+} to MnO_2

Calculate the simplest whole-number reacting ratio of Mn^{2+} ions to $NO3^-$ ions.

Determine the oxidation state of N at the end of the reaction.

Half-equation

_____

Calculation

Reacting ratio

Mn^{2+} : NO_3^-

_____ : _____

Oxidation state of N at the end of the reaction

_____

(Total 5 marks)

Q5

Which change shows an oxidation of vanadium?

A $V_2O_5 \longrightarrow 2\ VO_2$ ⬭

B $VO_2 \longrightarrow V^{2+}$ ⬭

C $VO_2 \longrightarrow V_2O_5$ ⬭

C $VO_2^+ \longrightarrow 2VO_2$ ⬭

(Total 1 mark)

Q6

This question is about Group 7 elements and their compounds.

Bromine is formed when $K_2Cr_2O_7$ reacts with sodium bromide in acidic conditions.

The ionic equation for this redox reaction is shown.

$14H^+ + Cr_2O_7^{2-} + 6Br^- \longrightarrow 2Cr^{3+} + 7H_2O + 3Br_2$

(a) Write the half-equation for the conversion of bromide ions into bromine.

_____

(1)

(b) Give the oxidation state of chromium in the $Cr_2O_7^{2-}$ ion.

_____

(1)

(c) Write the half-equation for the conversion of $Cr_2O_7^{2-}$ ions, in acidic conditions, into chromium(III) ions and water.

_____

(1)

(d) Chlorine is used as an oxidising agent in the extraction of bromine from seawater. In this process, chlorine gas is bubbled through a solution containing bromide ions.

Write the simplest ionic equation for the reaction of chlorine with bromide ions.

_____

(1)

(e) Explain why chlorine is a stronger oxidising agent than bromine.

_____

_____

_____

_____

(2)

(f) Concentrated sulfuric acid is reduced by some halide ions.

Identify a halide ion that reduces sulfuric acid to hydrogen sulfide.

Write an ionic equation for this reaction.

Halide ion _____

Equation _____

(2)

Q7 Redox and Quantitative

Hydrated ammonium iron(II) sulfate has the formula $(NH_4)_2Fe(SO_4)_2.xH_2O$

The value of *x* in this formula can be calculated using results from this redox titration.

Method

- Dissolve a known mass of hydrated ammonium iron(II) sulfate in dilute sulfuric acid to make 250 cm^3 of solution.
- Titrate 25.0 cm^3 portions of this solution with a solution of potassium manganate(VII).

The half-equations for the reactions that occur during this titration are shown.

$Fe^{2+} \longrightarrow Fe^{3+} + e^-$

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

Results

Mass of hydrated ammonium iron(II) sulfate	8.37 g
Mean titre of potassium manganate(VII) solution	22.85 cm^3
Concentration of potassium manganate(VII) solution	0.0187 mol dm^{-3}

(a) State the colour change at the end-point of the titration.

_____

(1)

(b) Use the results to calculate the relative formula mass of $(NH_4)_2Fe(SO_4)_2.xH_2O$

Relative formula mass _____

(4)

(c) Deduce the value of *x* in $(NH_4)_2Fe(SO_4)_2.xH_2O$

(If you were unable to calculate the relative formula mass in **part (b)**, you should use the value 356.0

This is **not** the correct value.)

x _____

(2)

(Total 7 marks)

Q8

Redox and Enthalpy

(a) Write an equation, including state symbols, for the reaction for which the energy change is the standard enthalpy of formation of nitric acid, $HNO_3(l)$.

_____

(1)

Some standard enthalpy of formation values ($\Delta_f H^\theta$) are shown in the table.

Substance	$H_2O(l)$	$NO_2(g)$	$O_2(g)$
$\Delta_f H^\theta$ / kJ mol^{-1}	–286	+34	0

(b) State why the value for the standard enthalpy of formation of $O_2(g)$ is zero.

_____

(1)

The following equation shows how nitric acid (HNO_3) is formed in the Ostwald Process.

$2H_2O(l) + 4NO_2(g) + O_2(g) \rightarrow 4HNO_3(l) \quad \Delta H = -254$ kJ mol^{-1}

(c) Use the standard enthalpies of formation in the table to calculate the standard enthalpy of formation of nitric acid.

Standard enthalpy of formation _____ kJ mol^{-1}

(3)

(d) Give the oxidation state of nitrogen in nitric acid.

Use oxidation states to explain why the reaction in question (c) involves the oxidation of nitrogen.

Oxidation state of nitrogen in nitric acid _____

Explanation _____

_____

_____

(2)

(Total 7 marks)

Q9

Which equation represents a redox reaction?

A $[Co(H_2O)_6]^{2+} + 4Cl^- \longrightarrow [CoCl_4]^{2-} + 6H_2O$ ⬭

B $[Fe(H_2O)_6]^{2+} + 2OH^- \longrightarrow [Fe(H_2O)_4(OH)_2] + 2H_2O$ ⬭

C $MnO_2 + 4HCl \longrightarrow MnCl_2 + 2H_2O + Cl_2$ ⬭

D $CO_2 + 2NaOH \longrightarrow Na_2CO_3 + H_2O$ ⬭

(Total 1 mark)

Q10

Which of the following shows chlorine in its correct oxidation states in the compounds shown?

	HCl	$KClO_3$	HClO	
A	−1	+3	+1	⬭
B	+1	−5	−1	⬭
C	−1	+5	+1	⬭
D	+1	+5	−1	⬭

(Total 1 mark)

Q11

Iodine reacts with concentrated nitric acid to produce nitrogen dioxide (NO_2).

(a) (i) Give the oxidation state of iodine in each of the following.

I_2 _____

HIO_3 _____

(2)

(ii) Complete the balancing of the following equation.

I_2 + $10HNO_3$ ⟶ .....HIO_3 + ...NO_2 + ...H_2O

(1)

(b) In industry, iodine is produced from the $NaIO_3$ that remains after sodium nitrate has been crystallised from the mineral Chile saltpetre.
The final stage involves the reaction between $NaIO_3$ and NaI in acidic solution.
Half-equations for the redox processes are given below.

$$IO_3^- + 5e^- + 6H^+ \longrightarrow 3H_2O + \frac{1}{2}I_2$$

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

Q12 REDOX AND USES OF CHLORINE

This question is about Group 7 chemistry.

(a) Sea water is a major source of iodine.
The iodine extracted from sea water is impure. It is purified in a two-stage process.

Stage **1** $I_2 + 2H_2O + SO_2 \longrightarrow 2HI + H_2SO_4$

Stage **2** $2HI + Cl_2 \longrightarrow I_2 + 2HCl$

(i) State the initial oxidation state and the final oxidation state of sulfur in Stage **1**.

Oxidation state of S in SO_2 _____

Oxidation state of S in H_2SO_4 _____

(2)

(ii) State, in terms of electrons, what has happened to chlorine in Stage **2**.

_____

_____

(1)

(b) When concentrated sulfuric acid is added to potassium iodide, iodine is formed in the following redox equations.

$\ldots\ldots KI + \ldots\ldots H_2SO_4 \longrightarrow \ldots\ldots KHSO_4 + \ldots\ldots I_2 + S + \ldots\ldots H_2O$

$8KI + 9H_2SO_4 \longrightarrow 8KHSO_4 + 4I_2 + H_2S + 4H_2O$

(i) Balance the equation for the reaction that forms sulfur.

(1)

(ii) Deduce the half-equation for the formation of iodine from iodide ions.

_____

(1)

(iii) Deduce the half-equation for the formation of hydrogen sulfide from concentrated sulfuric acid.

_____

(1)

(c) A yellow precipitate is formed when silver nitrate solution, acidified with dilute nitric acid, is added to an aqueous solution containing iodide ions.

(i) Write the **simplest ionic** equation for the formation of the yellow precipitate.

_____

(1)

(ii) State what is observed when concentrated ammonia solution is added to this yellow precipitate.

_____

_____

(1)

(iii) State why the silver nitrate solution is acidified when testing for iodide ions.

_____

_____

_____

(1)

(iv) Explain why dilute hydrochloric acid is **not** used to acidify the silver nitrate solution in this test for iodide ions.

_____

_____

_____

(1)

(d) Chlorine is toxic to humans. This toxicity does not prevent the large-scale use of chlorine in water treatment.

(i) Give **one** reason why water is treated with chlorine.

_____

_____

(1)

(ii) Explain why the toxicity of chlorine does **not** prevent this use.

_____

_____

_____

(1)

(iii) Write an equation for the reaction of chlorine with cold water.

_____

(1)

(e) Give the formulas of the **two** different chlorine-containing compounds that are formed when chlorine reacts with cold, dilute, aqueous sodium hydroxide.

Formula 1 _____

Formula 2 _____

(1)

(Total 14 marks)

Q13

Reactions that involve oxidation and reduction are used in a number of important industrial processes.

(a) Iodine can be extracted from seaweed by the oxidation of iodide ions.
In this extraction, seaweed is heated with MnO_2 and concentrated sulfuric acid.

(i) Give the oxidation state of manganese in MnO_2

_____

(1)

(ii) Write a half-equation for the reaction of MnO_2 in acid to form Mn^{2+} ions and water as the only products.

_____

(1)

(iii) In terms of electrons, state what happens to the iodide ions when they are oxidised.

_____

_____

(1)

(b) Chlorine is used in water treatment. When chlorine is added to cold water it reacts to form the acids HCl and HClO
The following equilibrium is established.

$Cl_2(aq) + H_2O(l) \rightleftharpoons H^+(aq) + Cl^-(aq) + HClO(aq)$

(i) Give the oxidation state of chlorine in Cl_2 and in HClO

Cl_2 _____

HClO _____

(2)

(ii) Deduce what happens to this equilibrium as the HClO reacts with bacteria in the water supply. Explain your answer.

_____

_____

_____

_____

_____

(2)

(c) Concentrated sulfuric acid is reduced when it reacts with solid potassium bromide. Concentrated sulfuric acid is **not** reduced when it reacts with solid potassium chloride.

(i) Write the two half-equations for the following redox reaction.

$2H^+ + 2Br^- + H_2SO_4 \longrightarrow Br_2 + SO_2 + 2H_2O$

Half-equation 1

_____

Half-equation 2

_____

(2)

(ii) Write an equation for the reaction of solid potassium chloride with concentrated sulfuric acid.

_____

(1)

(iii) Explain why chloride ions are weaker reducing agents than bromide ions.

_____

_____

_____

_____

(2)

(Total 12 marks)

Q14

Iodine reacts with concentrated nitric acid to produce nitrogen dioxide (NO_2).

(a) (i) Give the oxidation state of iodine in each of the following.

I_2 _____

HIO_3 _____

(2)

(ii) Complete the balancing of the following equation.

$$I_2 + 10HNO_3 \longrightarrow \text{.....}HIO_3 + \text{.....}NO_2 + \text{.....}H_2O$$

(1)

(b) In industry, iodine is produced from the $NaIO_3$ that remains after sodium nitrate has been crystallised from the mineral Chile saltpetre.
The final stage involves the reaction between $NaIO_3$ and NaI in acidic solution.
Half-equations for the redox processes are given below.

$$IO_3^- + 5e^- + 6H^+ \longrightarrow 3H_2O + \frac{1}{2}I_2$$

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

Use these half-equations to deduce an overall ionic equation for the production of iodine by this process. Identify the oxidising agent.

Overall ionic equation

The oxidising agent _____

(2)

(c) When concentrated sulfuric acid is added to potassium iodide, solid sulfur and a black solid are formed.

(i) Identify the black solid.

_____

(1)

(ii) Deduce the half-equation for the formation of sulfur from concentrated sulfuric acid.

_____

(1)

(d) When iodide ions react with concentrated sulfuric acid in a different redox reaction, the oxidation state of sulfur changes from +6 to -2. The reduction product of this reaction is a poisonous gas that has an unpleasant smell.
Identify this gas.

_____

(1)

(e) A yellow precipitate is formed when silver nitrate solution, acidified with dilute nitric acid, is added to an aqueous solution containing iodide ions.

(ii) Write the **simplest ionic** equation for the formation of the yellow precipitate.

_____

(1)

(ii) State what is observed when concentrated ammonia solution is added to this precipitate.

_____

_____

(1)

(iii) State why the silver nitrate is acidified when testing for iodide ions.

_____

_____

(1)

(f) Consider the following reaction in which iodide ions behave as reducing agents.

$$Cl_2(aq) + 2I^-(aq) \longrightarrow I_2(aq) + 2Cl^-(aq)$$

(i) In terms of electrons, state the meaning of the term *reducing agent*.

_____

_____

(1)

(ii) Write a half-equation for the conversion of chlorine into chloride ions.

_____

(1)

(iii) Suggest why iodide ions are stronger reducing agents than chloride ions.

_____

_____

_____

_____

(2)

(Total 15 marks)

MARK SCHEME

1

B

[1]

Q2

(a) gains electrons / electron acceptor

do not accept gains pair of electrons

1

(b) $SO_2 + 2H_2O \rightarrow SO_4^{2-} + 4H^+ + 2\ e^-$

1

(c) $Br_2 + SO_2 + 2H_2O \rightarrow 4H^+ + 2Br^- + SO_4^{2-}$

1

S has oxidation state of +4 in SO_2 and +6 on SO_4^{2-} (S oxidised)

1

Br oxidation state changes from 0 to –1 (Br is reduced)

1

(d) colourless (NaI solution) turns to a brown (solution) / black solid

1

$Br_2 + 2I^- \rightarrow 2Br^- + I_2$

or

$Br_2 + 2NaI \rightarrow 2NaBr + I_2$

allow multiples

1

[7]

Q3

i) Cl **or** chlorine

1

oxidation increases from 0 to +5 (in $NaClO_3$)

allow oxidation state increases by 5

1

Q4

$Mn^{2+} + 2\ H_2O \rightarrow MnO_2 + 4\ H^+ + 2\ e^-$

allow multiples

ignore state symbols

1

$n(Mn^{2+}) = \frac{24.0 \times 0.150}{1000} = 3.60 \times 10^{-3}$ (mol)

1

$n(NO_3^-) = \frac{15.0 \times 0.0960}{1000} = 1.44 \times 10^{-3}$ (mol)

1

(reacting ratio $\frac{3.60 \times 10^{-3}}{1.44 \times 10^{-3}} = 2.5$)

($Mn^{2+} : NO_3^-$ =) 5 : 2

1

(final oxidation state of N is) 0

1

[5]

Q5

C

[1]

Q6

(a) $2Br^- \longrightarrow Br_2 + 2e^-$

Allow multiples

1

(b) (+)6

1

(c) $Cr_2O_7^{2-} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O$

1

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

1

(e) Chlorine (atom / molecule) is smaller OR chlorine has less electron shells OR chlorine has less shielding

Accept converse statement for bromine (atom / molecule)

Attraction to outer electron is less (in Br)

1

Attraction to (outer / gained) electron in chlorine is stronger OR (gained / outer) electron is more tightly held

1

(f) I^-/ iodide

Allow astatide

1

$8H^+ + H_2SO_4 + 8I^- \longrightarrow H_2S + 4H_2O + 4I_2$

Allow equations with spectator ions

1

7 Redox and Quantiative

a) colourless to (pale) pink

Both colours needed

1

(b) M1 $n(MnO_4^-) = 0.0187 \times 0.02285$

$= 0.000427$ (mol)

M2 $n(Fe^{2+})$ in 25.0 $cm^3 = 5 \times 0.000427$

$= 0.002136$ (mol)

M2 = M1 × 5

M3 $n(Fe^{2+})$ in 250 $cm^3 = 10 \times 0.002135$

$= 0.02136$ (mol)

M3 = M2 × 10

M4 M_r (= 8.37 ÷ 0.02136) = 391.8 / 392

M4 = 8.37 ÷ M3

Correct final answer scores 4

4

(c) M1 M_r (anhydrous) = 284.0

M2 $x = \frac{392 - 284}{18} = 6$

M2 ECF from (b)

Final answer must be integer

Answer using provided value:

$x = \frac{356 - 284}{18} = 4$

2

[7]

Q8

(a) $\frac{1}{2}H_2(g) + \frac{1}{2}N_2(g) + \frac{3}{2}O_2(g) \rightarrow HNO_3(l)$

1

(b) It's an element (in its standard state) or by definition

1

(c) $\Delta H = \sum \Delta_f H$ products − $\sum \Delta_f H$ reactants OR a correct cycle OR

$-254 = 4\Delta_f H HNO_3 - [(2 \times -286) + (4 \times 34)]$

1

$4\Delta_f H HNO_3 = -690$ (kJ mol^{-1})

1

$\Delta_f H HNO_3 = -172.5$ (kJ mol^{-1})

If +172.5 max 1

1

(d) (+)5

1

N goes from +4 to +5 so has lost electron

1

[7]

Q9

C

[1]

Q10

C

[1]

Q11

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

M2 (+) 5

Accept Roman V for M2

2

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

Accept multiples

1

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

For M1, ignore state symbols

Credit multiples

Accept $2½I_2 + ½I_2$ 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) $H_2SO_4 + \mathbf{6}H^+ + \mathbf{6}e^- \longrightarrow S + \mathbf{4}H_2O$

Ignore state symbols

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

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 <u>white solid</u>

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

Ignore reference to "false positive"

- prevent the formation of other <u>silver precipitates / 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>
- react with / remove carbonate / hydroxide / sulfite (ions)

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

1

(f) (i) An <u>electron donor</u>

Penalise "electron pair donor"

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

Penalise "loss of electrons" alone

Accept "electron donator"

1

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

Ignore state symbols

Do not penalise absence of charge on electron

Credit $Cl_2 \longrightarrow \boldsymbol{2}Cl^- - \boldsymbol{2}e^-$

Credit multiples

1

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

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

M1 Relative size of <u>ions</u>

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

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

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

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

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

Insist on <u>iodide</u> ions in M1 and M2 or the use of it / they / them, in the correct context (or <u>chloride</u> 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]

Q12

(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 + **8**H^+ + **8**e^- ⟶ H_2S + **4**H_2O

OR

SO_4^{2-} + **10**H^+ + **8**e^- ⟶ H_2S + **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^- ⟶ 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

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

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]

Q13

(a) (i) MnO_2 (+) 4

1

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

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 $\mathbf{2}Br^- \longrightarrow Br_2 + \mathbf{2}e^-$

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

OR

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

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

$$\mathbf{2}KCl + H_2SO_4 \longrightarrow K_2SO_4 + \mathbf{2}HCl$$

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 <u>smaller</u> than bromide ions OR chloride ion electron(s) are <u>closer</u> 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]

Q14

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

M2 (+) 5

Accept Roman V for M2

2

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

Accept multiples

1

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

For M1, ignore state symbols

Credit multiples

Accept $2½I_2 + ½I_2$ 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) $H_2SO_4 + \mathbf{6}H^+ + \mathbf{6}e^- \longrightarrow S + \mathbf{4}H_2O$

Ignore state symbols

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

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 <u>white solid</u>

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

Ignore reference to "false positive"

- prevent the formation of other <u>silver precipitates / 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>
- react with / remove carbonate / hydroxide / sulfite (ions)

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

1

(f) (i) An <u>electron donor</u>

Penalise "electron pair donor"

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

Penalise "loss of electrons" alone

Accept "electron donator"

1

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

Ignore state symbols

Do not penalise absence of charge on electron

Credit $Cl_2 \longrightarrow \mathbf{2}Cl^- - \mathbf{2}e^-$

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

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