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A' Level Chemistry

Year 2

Unit 18: Reactions of Ions in Aqueous Solution

Summer Examination Revision Pack

The questions in this pack should be attempted **AFTER** completing all other revision.

Grade Accelerator

Recall Definitions
Drawing Diagrams
Using Equations
Drawing Graphs

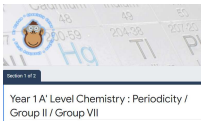
Quizlet

Quizlet Classes

Flashcard Based
Games
Tests & Quizzes
Keyword Spell Checker

Condensed Notes

Keywords & Definitions
Key Concepts
Application
Key Skills



Online Forms

Take Time to Answer
Use Paper & Calculator
Work It Out
Review Missed Marks

Use the 3 Wave Process when completing these revision packs.

1. Complete the questions without assistance
(Can't answer a question? Leave it and move on)
2. Use your notes to fill any gaps after step 1
3. Use the mark scheme to fill in any remaining gaps.

1. Having gaps after step 1 is normal, that's why we are doing revision!
2. If your notes don't help during step 2, they are not good enough!
(Change your note taking method and try to understand the problem)
3. If you don't understand why the mark scheme answer is correct, **see Andy.**

If you struggle with the questions in the pack, **STOP!** and complete some more revision.

If you come to a complete dead-end, **STOP!** and speak to **Andy** asap.

0 7 Solution **A** contains the compound $[Cu(H_2O)_6]Cl_2$

0 7 . 1 State the type of bonding between the oxygen and hydrogen in this compound.

[1 mark]

0 7 . 2 State why the chloride ions in this compound are **not** considered to be ligands.

[1 mark]

0 7 . 3 An excess of ammonia was added to a sample of solution **A** to form solution **B**.

Write an ionic equation for the reaction that occurs when solution **A** is converted into solution **B** and state the colour of solution **B**.

[2 marks]

Equation

Colour

0 7 . 4 Aqueous sodium carbonate was added to another sample of solution **A** to form a blue-green solid **C**.

Identify the blue-green solid **C**.

[1 mark]

0 7 . 5 Reagent **D** was added to another sample of solution **A** to form a yellow-green solution.

Identify reagent **D** and write an ionic equation for the reaction that occurs when the yellow-green solution is formed from solution **A**.

[2 marks]

Identity of reagent **D**

Equation

0 7 . 6 Explain why colorimetry cannot be used to determine the concentration of solutions containing $[CuCl_2]^-$
In your answer refer to the electron configuration of the metal ion.

[2 marks]

9

Turn over for the next question

Question	Answers	Mark	Additional Comments/Guidance
07.1	Covalent	1	Do not allow dative covalent or coordinate (covalent)
07.2	$Cl^{(-)}$ not donating lone pair (to $Cu^{(2+)}$) $Cl^{(-)}$ does not form a coordinate/dative bond (to $Cu^{(2+)}$)	1	Allow without charges but penalise incorrect charges Cl^-/it is bonded ionically (to Cu^{2+})
07.3	$[Cu(H_2O)_6]^{2+} + 4NH_3 \rightarrow [Cu(NH_3)_4(H_2O)_2]^{2+} + 4H_2O$ Deep blue / Royal blue / Dark blue (solution)	1 1	Allow combination of: $[Cu(H_2O)_6]^{2+} + 2NH_3 \rightarrow [Cu(H_2O)_4(OH)_2] + 2NH_4^+$ $[Cu(H_2O)_4(OH)_2] + 4NH_3 \rightarrow [Cu(NH_3)_4(H_2O)_2]^{2+} + 2H_2O + 2OH^-$ Do not penalise missing square brackets Ignore initial colour of Cu^{2+} (aq)
07.4	$CuCO_3$ or copper carbonate	1	Penalise incorrect oxidation state Allow correct formula for basic copper carbonate
07.5	HCl/ hydrochloric acid $[Cu(H_2O)_6]^{2+} + 4Cl^- \rightarrow [CuCl_4]^{2-} + 6H_2O$ $[Cu(H_2O)_6]^{2+} + 4HCl \rightarrow [CuCl_4]^{2-} + 6H_2O + 4H^+$	1 1	Ignore concentration Allow soluble chloride salt Also allow any reagent which leads to a change in colour of solution due to a change in ligands (eg $NH_2CH_2CH_2NH_2$) or change in oxidation state (eg SO_2) and associated correct equations. Mark independently

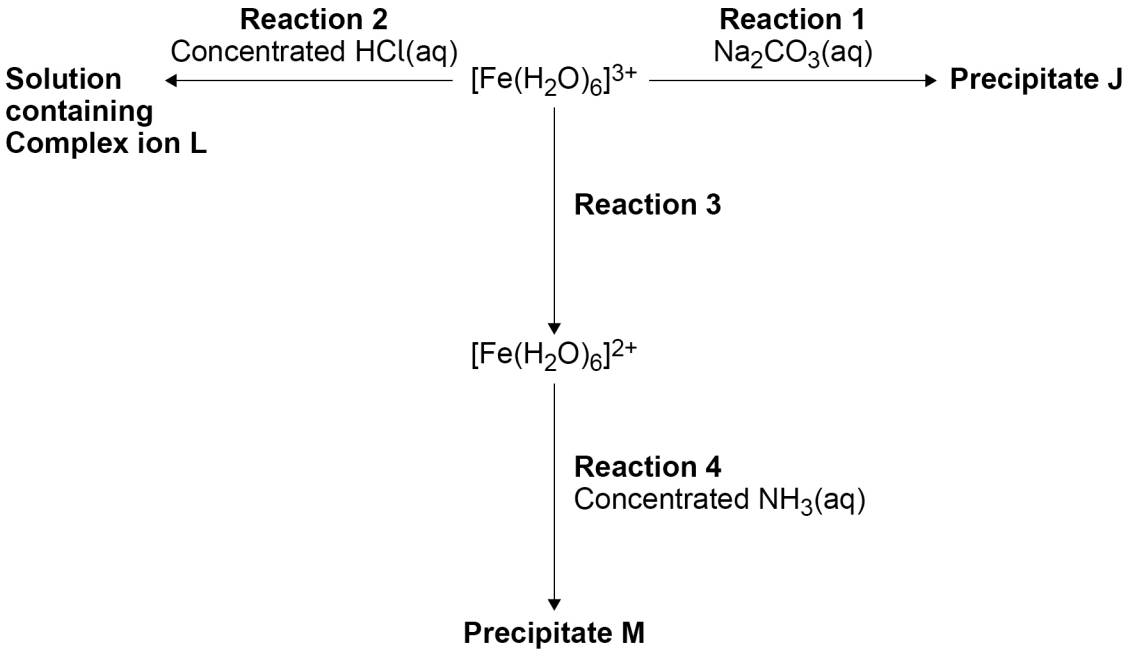
07.6	(3)d^{10} or has full (3)d (sub) shell/orbital It is colourless/cannot absorb (frequencies of) visible light	1 1	Penalise incorrect principal quantum number Ignore clear

Total		**9**	

Do not write outside the box

0 4 **Figure 3** shows some reactions of aqueous iron ions.

Figure 3



0 4 . 1 Give the formula of **Precipitate J** and state its colour.
Give an equation for **Reaction 1**.

[3 marks]

Formula of **J** _____

Colour _____

Equation

_____

0 4 . 2 Give the formula of **L** and an equation for **Reaction 2**.

[2 marks]

Formula of **L** _____

Equation

_____

0 4 . 3 Suggest a reagent for **Reaction 3**.

[1 mark]

_____

Turn over ►

Do not write outside the box

0 4 . 4 Give the formula of **Precipitate M** and state its colour.

[2 marks]

Formula of **M** _____

Colour _____

0 4 . 5 Transition metal complexes have different shapes and many show isomerism.

Describe the different shapes of complexes and show how they lead to different types of isomerism.
Use examples of complexes of cobalt(II) and platinum(II).

You should draw the structures of the examples chosen.

[6 marks]

Do not write outside the box

14

Turn over ►

Question	Answers	Additional Comments/Guidelines	Mark
04.1	$[Fe(OH)_3(H_2O)_3]$ Brown $2[Fe(H_2O)_6]^{3+} + 3CO_3^{2-} \rightarrow 2[Fe(OH)_3(H_2O)_3] + 3CO_2 + 3H_2O$	 M2: Allow red-brown M3: Allow correct equations with Na_2CO_3 M3: Ignore state symbols	1 1 1
04.2	$[FeCl_4]^-$ $[Fe(H_2O)_6]^{3+} + 4Cl^- \rightarrow [FeCl_4]^- + 6H_2O$	 M2: Allow correct equations with HCl	1 1
04.3	(XS) Zn (in acid or HCl or H_2SO_4)	Allow KI/potassium iodide	1
04.4	$[Fe(OH)_2(H_2O)_4]$ green		1 1

04.5	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** **5–6 marks** All stages are covered and the description of each stage is generally correct and virtually complete. Answer is communicated coherently and shows a logical progression from stage 1 to stage 2 and stage 3 Answer is illustrated using diagrams of at least 2 specific examples of pairs of cobalt or platinum complex isomers. **Level 2** **3–4 marks** All stages are covered but the description 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 progression from stage 1 to stage 2 and/or stage 3. Answer is illustrated using diagrams of at least 1 specific example of a pair of cobalt or platinum complex isomers. **Level 1** **1–2 marks** Two stages are covered but the description 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 isolated statements and these are presented in a logical order. Answer is illustrated using at least 1 appropriate diagram or formula. **Level 0** **0 marks** Insufficient correct chemistry to gain a mark.	**Indicative Chemistry content** **Stage 1: shapes of complexes** 1a octahedral or 6 co-ordinate diagram 1b tetrahedral or square planar or 4 co-ordinate diagram **Stage 2: cis/ trans isomerism (or E-Z or geometric)** 2a cis/trans isomerism in either square planar and/or octahedral complexes 2b Diagrams showing cis <u>and</u> trans isomerism in a square planar complex 2c Diagrams showing cis <u>and</u> trans isomers of octahdedral complexes eg draw cis <u>and</u> trans $M(H_2O)_4(OH)_2$ or $[M(NH_3)_4(H_2O)_2]^{2+}$ **Stage 3: optical isomerism** 3a optical isomerism / non superimposable mirror images in octahedral complexes 3b occurs with a specific bidentate ligands eg.$C_2O_4^{2-}$ or $NH_2CH_2CH_2NH_2$ 3c draw both optical isomers of eg $[M(NH_2CH_2CH_2NH_2)_3]^{2+}$	6

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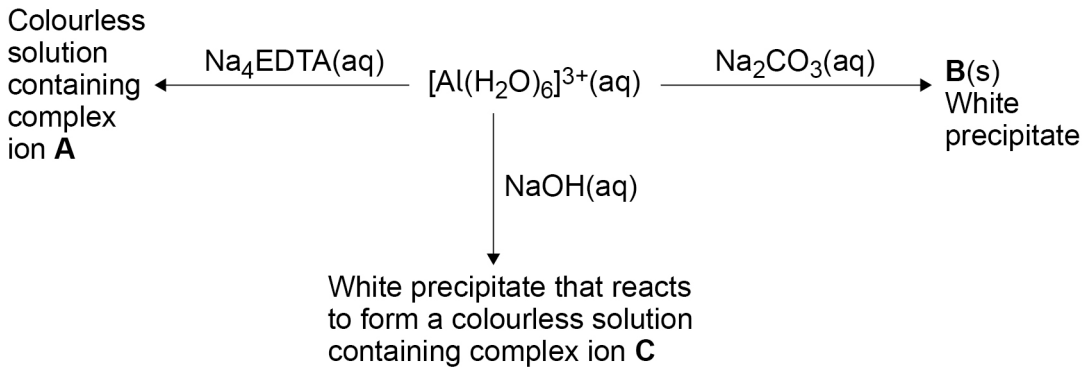
0 5 Some reactions of the $[Al(H_2O)_6]^{3+}(aq)$ ion are shown.



0 5 . 1 Give the formula of the white precipitate **B**.

State **one** other observation when $Na_2CO_3(aq)$ is added to a solution containing $[Al(H_2O)_6]^{3+}(aq)$ ions.

Give an equation for this reaction.

[3 marks]

Formula of **B** _____

Observation _____

Equation

_____

0 5 . 2 Give the formula of the complex ion **C**.

State **one** condition needed for the formation of **C** from $[Al(H_2O)_6]^{3+}(aq)$ and NaOH(aq).

Give an equation for this reaction.

[3 marks]

Formula of **C** _____

Condition _____

Equation

_____

Do not write outside the box

0 5 . 3 Deduce the formula of the complex ion **A**.

[1 mark]

0 5 . 4 Explain, with the use of an equation, why a solution containing $[Al(H_2O)_6]^{3+}$ has a pH <7

[3 marks]

Equation

Explanation

10

Turn over for the next question

Question	Answers	Additional comments/Guidelines	Mark
05.1	M1 **B** = $Al(H_2O)_3(OH)_3$ M2 bubbles/effervescence M3 $2\ [Al(H_2O)_6]^{3+} + 3CO_3^{2-} \rightarrow 2\ Al(H_2O)_3(OH)_3 + 3H_2O + 3CO_2$	Ignore [ ] M2 Do not allow gas evolved M3 Ignore absence of square brackets around Al complex M3 Allow correct balanced equations with Na_2CO_3	1 1 1
05.2	M1 **C** = $[Al(OH)_4]^-$ OR $[Al(H_2O)_2(OH)_4]^-$ OR $[Al(OH)_6]^{3-}$ M2 Excess NaOH M3 $[Al(H_2O)_6]^{3+} + 4\ OH^- \rightarrow [Al(OH)_4]^- + 6\ H_2O$ OR $[Al(H_2O)_6]^{3+} + 4\ OH^- \rightarrow [Al(H_2O)_2(OH)_4]^- + 4\ H_2O$ OR $[Al(H_2O)_6]^{3+} + 6\ OH^- \rightarrow [Al(OH)_6]^{3-} + 6\ H_2O$	M2 Allow excess OH^- M3 Allow equations to form $Al(H_2O)(OH)_5^{2-}$ M3 Allow correct balanced equations with NaOH	1 1 1
05.3	$[Al(EDTA)]^-$	Do not penalise absence of square brackets	1
05.4	M1 $[Al(H_2O)_6]^{3+} + H_2O \rightleftharpoons [Al(H_2O)_5(OH)]^{2+} + H_3O^+$ OR $[Al(H_2O)_6]^{3+} \rightleftharpoons [Al(H_2O)_5(OH)]^{2+} + H^+$ M2 $\underline{Al^{3+}}$ has a small size <u>and</u> high charge OR has a high charge density M3 Weakens the OH bond (in water) releasing H^+ ions	Accept other equations M2 Allow the aluminium ion has a small size <u>and</u> high charge OR has a high charge density	1 1 1

Do not write outside the box

0 4 This question is about iron and its ions.

0 4 . 1 Discuss the role of iron as a heterogeneous catalyst in the Haber process.

$$3\,H_2 + N_2 \rightleftharpoons 2\,NH_3$$

Your answer should include:

- the meaning of the term heterogeneous catalyst
- how iron acts as a heterogeneous catalyst
- the factors that affect the efficiency and lifetime of the catalyst.

[6 marks]

Do not write outside the box

Do not write outside the box

0 4 . 2 Fe^{2+} ions catalyse the reaction between peroxodisulfate(VI) ions and iodide ions in aqueous solution.

$$S_2O_8^{2-}(aq) + 2\,I^-(aq) \rightarrow 2\,SO_4^{2-}(aq) + I_2(aq)$$

Explain why this reaction is slow before the catalyst is added.
Give **two** equations to show how Fe^{2+} ions catalyse this reaction.

[4 marks]

Why reaction is slow before catalyst added

Equation 1

Equation 2

0 4 . 3 Give a reason why Zn^{2+} ions do **not** catalyse the reaction in Question **04.2**.

[1 mark]

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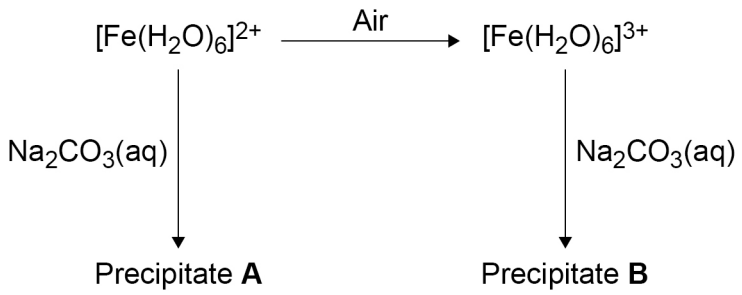
Figure 2 shows some reactions of iron ions in aqueous solution.

Figure 2



0 4 . 5 Identify **A** and state its colour.

[2 marks]

Identity _____

Colour _____

0 4 . 6 Give the formula of **B** and state its colour.

Give an ionic equation for the reaction of $[Fe(H_2O)_6]^{3+}$ with aqueous Na_2CO_3 to form **B**.

[3 marks]

Formula _____

Colour _____

Ionic equation

_____

Do not write outside the box

0 4 . 7 Explain why an aqueous solution containing $[Fe(H_2O)_6]^{3+}$ ions has a lower pH than an aqueous solution containing $[Fe(H_2O)_6]^{2+}$ ions.

[3 marks]

25

Turn over for the next question

Question	Answers	Additional comments/Guidelines	Mark
04.1	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** **5–6 marks** All stages are covered and the description of each stage is generally correct and virtually complete. Answer is communicated coherently and shows a logical progression from stage 1 to stage 2 and stage 3. **Level 2** **3–4 marks** All stages are covered but the description 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 progression from stage 1 to stage 2 and/or stage 3. **Level 1** **1–2 marks** Two stages are covered but the description 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 isolated statements and these are presented in a logical order. **Level 0** **0 marks** Insufficient correct chemistry to gain a mark.	Stage 1 1a Heterogeneous means in a different phase/state from reactants 1b Catalyst speeds up reaction and is left unchanged **OR** lowers the activation energy for the reaction Stage 2 2a Hydrogen and nitrogen/reactants adsorb onto the surface/ active sites of the iron 2b Bonds weaken/reaction takes place 2c Products desorb/leave from the surface (of the iron) Stage 3 3a Large surface area (of iron) by using powder or small pellets or support medium/mesh 3b Catalyst poisoned / sulfur poisons or binds to the catalyst 3c Active sites blocked Ignore references to temperature and pressure	6

Question	Answers	Additional comments/Guidelines	Mark
04.2	Two negative ions repel So activation energy is high $2\ Fe^{2+} + S_2O_8^{2-} \rightarrow 2\ SO_4^{2-} + 2\ Fe^{3+}$ $2\ Fe^{3+} + 2\ I^- \rightarrow 2\ Fe^{2+} + I_2$	 Ignore any state symbols given Allow multiples for both equations Allow equations in either order	1 1 1 1

Question	Answers	Additional comments/Guidelines	Mark
04.3	(Zn ions) have only one oxidation state Or Zn^{2+} is the only ion	Allow doesn't have variable oxidation state Allow cannot be oxidised to Zn^{3+} Ignore has a full d shell	1

Question	Answers	Additional comments/Guidelines	Mark
04.5	$FeCO_3$ or iron(II) carbonate		1
	Green	Allow white	1

Question	Answers	Additional comments/Guidelines	Mark
04.6	$Fe(H_2O)_3(OH)_3$	Ignore square brackets if added	1
	brown		1
	$2\ [Fe(H_2O)_6]^{3+} + 3\ CO_3^{2-} \rightarrow 2\ Fe(H_2O)_3(OH)_3 + 3\ H_2O + 3\ CO_2$	Accept multiples	1

Question	Answers	Additional comments/Guidelines	Mark
04.7	M1 Fe^{3+} is smaller (than Fe^{2+}) **OR** Fe^{3+} has a greater charge **OR** Fe^{3+} has a greater charge density **OR** Fe^{3+} has a greater charge to size ratio	Penalise $Fe(H_2O)_6^{3+}$ ions once in M1 or M2	1
	M2 Fe^{3+} ions are more polarising **OR** Fe^{3+} ions polarise water molecules more		1
	M3 So more O-H bonds (in the water ligands) break **OR** more H^+ ions released **OR** weaken O-H bonds in ligands more (in the Fe^{3+} solution)	Do not allow Fe^{3+} releases $3H^+$ ions	1

Do not write outside the box

0 5 This question is about catalysis.

0 5 . 1 Zeolites are used as heterogeneous catalysts in the catalytic cracking of alkanes.

Tetradecane ($C_{14}H_{30}$) can be cracked to form octane and a cycloalkane.

Give an equation for this reaction.

State the meaning of the term heterogeneous.

[2 marks]

Equation

Heterogeneous

0 5 . 2 A student determines the concentration of ethanedioate ions in an acidified solution by titration with potassium manganate(VII) solution.

$$2\,MnO_4^- + 5\,C_2O_4^{2-} + 16\,H^+ \rightarrow 2\,Mn^{2+} + 10\,CO_2 + 8\,H_2O$$

The mixture is warmed before the addition of potassium manganate(VII) solution because the reaction is slow at first. When more potassium manganate(VII) solution is added, the mixture goes colourless quickly due to the presence of an autocatalyst.

Explain the meaning of the term autocatalyst.

Explain, using equations where appropriate, why the reaction is slow at first and then goes quickly.

[6 marks]

Do not write outside the box

0 5 . 3 The reaction between peroxodisulfate ions and iodide ions in aqueous solution can be catalysed by Co^{2+} ions.

$$S_2O_8^{2-} + 2\,I^- \rightarrow 2\,SO_4^{2-} + I_2$$

Table 6 gives relevant standard electrode potentials.

Table 6

Electrode half-equation	$E^{\ominus}$ / V
$S_2O_8^{2-}(aq) + 2\,e^- \rightarrow 2\,SO_4^{2-}(aq)$	+2.01
$Co^{3+}(aq) + e^- \rightarrow Co^{2+}(aq)$	+1.82
$I_2(aq) + 2\,e^- \rightarrow 2\,I^-(aq)$	+0.54

Use the electrode potential data to suggest how Co^{2+} catalyses the reaction.

[3 marks]

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Question	Answers	Additional Comments/Guidelines	Mark
05.1	**M1** $C_{14}H_{30} \rightarrow C_6H_{12} + C_8H_{18}$ or $C_{14}H_{30} \rightarrow 2\ C_3H_6 + C_8H_{18}$ **M2** **(**catalyst is in) different phase/state (to reactants)	**M1** Allow any correct structural representation of tetradecane, octane, and a cycloalkane with formula C_6H_{12} OR C_3H_6 **M2** Assume that 'it' refers to the catalyst **Allow** ……. to reactants and products **Not** …… to products	1 1 (1 x AO1, 1 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
05.2	**M1** autocatalyst: product of the reaction catalyses the reaction **M2** slow: negative ions repel / ions of same charge repel **M3** high E_a **M4** attraction between oppositely charged ions / negative reactant ion(s) and positive catalyst / Mn^{2+} / Mn^{3+} **M5** $4\ Mn^{2+} + MnO_4^- + 8\ H^+ \rightarrow 5\ Mn^{3+} + 4\ H_2O$ **M6** $2\ Mn^{3+} + C_2O_4^{2-} \rightarrow 2\ Mn^{2+} + 2\ CO_2$	**Not** 'reactant' **Allow** catalyst reduces E_a as an alternative for **M3** **Not** catalyst reduces E_a as an alternative for **M4** **Ignore** state symbols	1 1 1 1 1 1 (6 x AO1)

Question	Answers	Additional Comments/Guidelines	Mark
05.3	**M1** idea of change from Co^{2+} to Co^{3+} and back to Co^{2+}		1
	M2 $E^{\ominus}$ $S_2O_8^{2-}$ / SO_4^{2-} > $E^{\ominus}$ Co^{3+} / Co^{2+} and so $S_2O_8^{2-}$ ions oxidise Co^{2+} **or** Co^{2+} ions reduce $S_2O_8^{2-}$	**M2 alternatives** electrode potential for $S_2O_8^{2-}$ greater than Co^{3+} so $S_2O_8^{2-}$ ions oxidise Co^{2+} **or** Co^{2+} ions reduce $S_2O_8^{2-}$ **OR** 2.01 (V) > 1.82 (V) so $S_2O_8^{2-}$ ions oxidise Co^{2+} **or** Co^{2+} ions reduce $S_2O_8^{2-}$ **OR** $2\ Co^{2+} + S_2O_8^{2-} \rightarrow 2\ Co^{3+} + 2\ SO_4^{2-}$ E_{cell} = (+)0.19 (V)	1
	M3 $E^{\ominus}$ Co^{3+} /Co^{2+} > $E^{\ominus}$ I_2 /I^- and so Co^{3+} ions oxidise I^- **or** I^- ions reduce Co^{3+}	**M3 alternatives** electrode potential for Co^{3+} greater than I_2 so Co^{3+} ions oxidise I^- **or** I^- ions reduce Co^{3+} **OR** 1.82 (V) > 0.54 (V) so Co^{3+} ions oxidise I^- **or** I^- ions reduce Co^{3+} **OR** $2\ Co^{3+} + 2\ I^- \rightarrow 2\ Co^{2+} + I_2$ E_{cell} = (+)1.28 (V) for **M2** and **M3 Allow** 1 mark (out of 2 marks) (if neither M2 or M3 already given) for combined: Co^{2+} ions reduce $S_2O_8^{2-}$ <u>AND</u> Co^{3+} oxidises I^-, **OR** $2\ Co^{2+} + S_2O_8^{2-} \rightarrow 2\ Co^{3+} + 2\ SO_4^{2-}$ **<u>AND</u>** $2\ Co^{3+} + 2\ I^- \rightarrow 2\ Co^{2+} + I_2$ **Not** if with negative E_{cell} value **Allow** if incorrect positive E_{cell} values	1 (3 x AO3)