**M1.**(a) To reduce any $Fe^{3+}$ ions to $Fe^{2+}$ ions

*Allow 'to ensure that all of the iron present is in the form of $Fe^{2+}$ ions' or 'to ensure that no $Fe^{3+}$ ions are present'.*

**1**

(b) Zinc would react with $MnO_4^-$ / $Fe^{3+}$ produced in titration

*Do not allow 'would increase titre value'.*

*Do not allow 'zinc would react' without further qualification.*

**1**

**[2]**

**M2.**(a) (i) Flask with side arm

**1**

Buchner funnel and horizontal filter paper

*Allow Hirsch funnel and horizontal filter paper.*

*Do not allow standard Y-shaped funnel.*

*If there is not a clear air-tight seal (labelled or drawn) between the funnel and the flask maximum 1 mark.*

**1**

(ii) $M_r$ $KMnO_4$ = 158(.0)

**1**

Mass = 0.225 × 158 / 3 = 11.9 (g)

*Lose M2 if no working shown.*

*Allow consequential mark on an incorrect $M_r$ for $KMnO_4$*

**1**

Precision mark: three significant figures

*Allow if mass incorrect.*

**1**

(iii) (Unpleasant) taste

*Ignore smell.*

**1**

(b) Difficult to see meniscus / line on graduated flask

*Do not allow reference to over filling.*

**1**

**[7]**

**M3.**(a) $2MnO_4^- + 16H^+ + 5C_2O_4^{2-} \longrightarrow 2Mn^{2+} + 8H_2O + 10CO_2$

*For all species correct / moles and species correct but charge incorrect*

**1**

*For balanced equation including all charges (also scores first mark)*

**1**

(b) Manganate(VII) ions are coloured (purple)

**1**

All other reactants and products are **not** coloured (or too faintly coloured to detect)

*Allow (all) other species are colourless*

*Allow $Mn^{2+}$ are colourless / becomes colourless / pale pink*

**1**

(c) The catalyst for the reaction is a reaction product

**1**

Reaction starts off slowly / gradient shallow

**1**

Then gets faster/rate increases / gradient increases

*Allow concentration of $MnO_4^-$ decreases faster / falls rapidly*

**1**

(d) $Mn^{2+}$ ions

*Allow $Mn^{3+}$ ions*

**1**

(e) $MnO_4^- + 8H^+ + 4Mn^{2+} \longrightarrow 5Mn^{3+} + 4H_2O$

*Allow multiples*

**1**

$2Mn^{3+} + C_2O_4^{2-} \longrightarrow 2Mn^{2+} + 2CO_2$

**1**

**[10]**

**M4.**(a) Stop the formation of $MnO_2$ / Ensures all $MnO_4^-$ reacts to form $Mn^{2+}$ / becomes colourless

**1**

(b) Weak acid / Does not supply sufficient $H^+$

**1**

(c) It is self-indicating / Purple to colourless end-point or vice versa

*If colours mentioned they must be correct.*

**1**

**[3]**

**M5.**(a) Manganate would oxidise / react with $\underline{Cl}^-$

**1**

Because $E^\ominus$ for $MnO_4^-$ is more positive than that for $Cl^2$ / 1.51 – 1.36 = +0.15 (V)

*Must refer to data from the table for M2.*

**1**

(b) Moles of $H^+ = 25 \times 0.0200 \times 8 / 1000 = 4.00 \times 10^{-3}$

**1**

Moles of $H_2SO_4 = 2.00 \times 10^{-3}$ ($4.00 \times 10^{-3} / 2$)

*Allow consequential marking on incorrect moles of $H^+$*

**1**

Volume $H_2SO_4 = 4.00$ ($cm^3$) ($2.00 \times 10^{-3} \times 1000 / 0.500$)

*Allow consequential marking on incorrect moles of $H_2SO_4$*
*Accept 4 $cm^3$.*
*8 $cm^3$ scores 2 marks.*
*Do not penalise precision.*
*Correct answer without working scores M3 only.*

**1**

(c) (i) $MnO_4^- + 4H^+ + 3e^- \rightarrow MnO_2 + 2H_2O$

*Allow multiples, including fractions.*
*Ignore state symbols.*

**1**

(ii) Can't see end point due to brown colour

**1**

<u>Larger</u> titre (than expected)

*Allow the idea that with two reactions can't make use of titre in calculations.*
*Do not allow 'an inaccurate result' without qualification.*

**1**

(d) Solution (very) dilute / lots of water

**1**

**[9]**

**M6.**(a)*For reactions 1 to 3 must show complex ions as reactants and products*
*Take care to look for possible identification on flow chart*

**Reaction 1**

ammonia solution

**1**

**W** is $[Co(NH_3)_6]^{2+}$

**1**

$[Co(H_2O)_6]^{2+} + 6NH_3 \rightarrow [Co(NH_3)_6]^{2+} + 6H_2O$
*Correct equation scores all 3 marks*

**1**

**Reaction 2**
*Allow oxygen, Do not allow air*

$H_2O_2$

**1**

**X** is $[Co(NH_3)_6]^{3+}$

**1**

$2[Co(NH_3)_6]^{2+} + H_2O_2 \rightarrow 2[Co(NH_3)_6]^{3+} + 2OH^-$
*Allow $2[Co(NH_3)_6]^{2+} + ½O_2 + H_2O \rightarrow 2[Co(NH_3)_6]^{3+} + 2OH^-$*
*Correct equations score all 3 marks*

**1**

**Reaction 3**

HCl
*Do not allow $Cl^-$ but mark on*

**1**

**Y** is $[CoCl_4]^{2-}$

1

$[Co(H_2O)_6]^{2+} + 4Cl^- \rightarrow [CoCl_4]^{2-} + 6H_2O$/

*Correct equation scores previous mark*

$[Co(H_2O)_6]^{2+} + 4HCl \rightarrow [CoCl_4]^{2-} + 6H_2O + 4H_+$

*This equation scores all three marks*

1

**Reaction 4**

$Na_2CO_3$ Or $NaOH/NH_3$

*Do not allow $CaCO_3$ as a reagent but mark on*

1

**Z** is $CoCO_3$ $Co(OH)_2/Co(H_2O)_4(OH)_2$

1

$[Co(H_2O)_6]^{2+} + CO_3^{2-} \rightarrow CoCO_3 + 6H_2O$ $[Co(H_2O)_6]^{2+} + 2OH^- \rightarrow Co(H_2O)_4(OH)_2 + 2H_2O$ etc

*Allow waters to stay co-ordinated to Co. This mark also previous mark*

Or $[Co(H_2O)_6]^{2+} + Na_2CO_3 \rightarrow CoCO_3 + 6H_2O + 2Na^+$

*Allow $Co^{2+} + CO_3^{2-} \rightarrow CoCO_3$*

1

(b) $SO_3^{2-} + ½O_2 \rightarrow SO_4^{2-}$

*Allow multiples*

1

The activation energy is lower (for the catalysed route)

*Or $Co^{3+}$ attracts $SO_3^{2-}$/$Co^{2+}$ attracts $SO_3^{2-}$/oppositely charged ions attract*

1

$½O_2 + 2Co^{2+} + 2H^+ \rightarrow H_2O + 2Co^{3+}$

1

$2Co^{3+} + SO_3^{2-} + H_2O \rightarrow 2Co^{2+} + SO_4^{2-} + 2H^+$

*Allow these equations in either order*

**1**

**[16]**