M1.(a)   Variable oxidation state

1

eg Fe(II) and Fe (III)

> *Any correctly identified pair*
> *Allow two formulae showing complexes with different oxidation states even if oxidation state not given*

1

(Characteristic) colour (of complexes)

1

eg Cu^{2+}<u>(aq)</u> / $[Cu(H_2O)_6]^{2+}$ is blue

> *Any correct ion with colour scores M3 and M4*
> *Must show (aq) or ligands OR identified coloured compounde.g. $CoCO_3$)*

1

(b)   Tetrahedral

1

$[CuCl_4]^{2-}$ / $[CoCl_4]^{2-}$

> *Any correct complex*
> *(Note charges must be correct)*

1

Square planar

1

$(NH_3)_2PtCl_2$

> *Any correct complex*

1

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Linear

Do not allow linear planar

1

$[Ag(NH_3)_2]^+$

$[AgCl_2]^-$ etc

1

(c) (i) $[Ca(H_2O)_6]^{2+} + EDTA^{4-} \rightarrow [CaEDTA]^{2-} + 6H_2O$

If equation does not show increase in number of moles of particles CE = 0/3 for (c)(ii)
If no equation, mark on

1

(ii) 2 mol of reactants form 7 mol of products

Allow more moles/species of products
Allow consequential to (c)(i)

1

Therefore disorder increases

1

Entropy increases / +ve entropy change / free-energy change is negative

1

(iii) Moles EDTA = 6.25 × 0.0532 / 1000 = (3.325 × 10⁻⁴)

1

Moles of Ca^{2+} in 1 dm³ = 3.325 × 10⁻⁴ × 1000 / 150 = (2.217 × 10⁻³)

*Mark is for M1 × 1000 / 150 **OR** M1 × 74.1*
If ratio of Ca^{2+} : EDTA is wrong or 1000 / 150 is wrong, CE and can score M1 only
This applies to the alternative

1

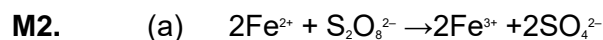Mass of $Ca(OH)_2$ = 2.217 × 10⁻³ × 74.1 = 0.164 g

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M1 × 74.1 × 1000 / 150
Answer expressed to 3 sig figs or better
Must give unit to score mark
Allow 0.164 to 0.165

1

[17]

M2.   (a) $2Fe^{2+} + S_2O_8^{2-} \rightarrow 2Fe^{3+} + 2SO_4^{2-}$

1

$2Fe^{3+} + 2I^- \rightarrow 2Fe^{2+} + I_2$
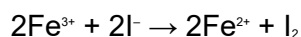
1

two negative ions repel / lead to reaction that is slow / lead to reaction that has high E_a
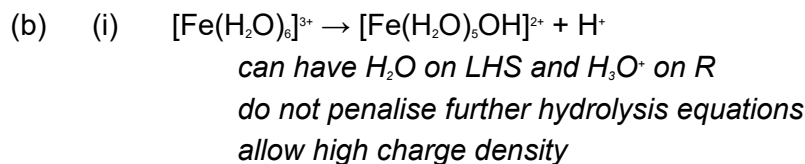
1

iron able to act because changes its oxidation state
        allow iron has variable oxidation state

1

With iron ions have alternative route / route with lower activation energy
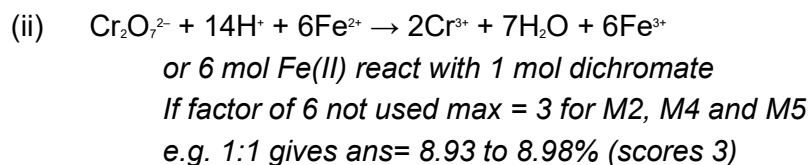
1

(b)   (i) $[Fe(H_2O)_6]^{3+} \rightarrow [Fe(H_2O)_5OH]^{2+} + H^+$
        can have H_2O on LHS and H_3O^+ on R
        do not penalise further hydrolysis equations
        allow high charge density

1

Fe^{3+} ion has hig<u>her</u> charge (to size ratio) (than Fe^{2+})

1

increases polarisation of co-ordinated water / attracts O releasing an H^+ ion / weakens O–H bond

1

(ii) $Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+} \rightarrow 2Cr^{3+} + 7H_2O + 6Fe^{3+}$
        or 6 mol Fe(II) react with 1 mol dichromate
        If factor of 6 not used max = 3 for M2, M4 and M5
        e.g. 1:1 gives ans= 8.93 to 8.98% (scores 3)

1

moles dichromate = 23.6 × 0.218/1000 = 5.14 × 10⁻⁴

1

moles iron = $5.14 \times 10^{-4} \times 6 = 0.00309$

M3 also scores M1

1

mass iron = $0.00309 \times 55.8 = 0.172$

Mark is for moles of iron × 55.8 conseq
Allow use of 56 for iron

1

% by mass of iron = $0.172 \times 100/0.321 = 53.7\%$

Answer must be to at least 3 sig figures allow 53.6 to 53.9
Mark is for mass of iron × 100/0.321 conseq

1

(c)   brown precipitate / solid
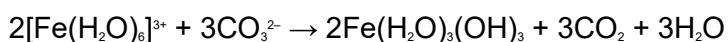
Allow red-brown / orange solid
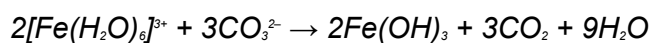*Not red or yellow solid*

1

bubbles (of gas) / effervescence/ fizz

Allow gas evolved / given off
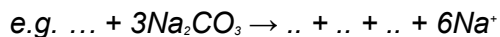*Do not allow just gas or CO_2 or CO_2 gas*

1

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

Allow
$2[Fe(H_2O)_6]^{3+} + 3CO_3^{2-} \rightarrow 2Fe(OH)_3 + 3CO_2 + 9H_2O$
Use of Na_2CO_3
e.g. … + $3Na_2CO_3 \rightarrow$ .. + .. + .. + $6Na^+$

1

[16]

M3.MnO_4^- will oxidise the <u>chloride</u> ion / reaction of MnO_4^- and Cl^- feasible

Accept converse argument with $Cr_2O_7^{2-}$
Accept calculations of overall E° values.

1

Larger volume needed

1

[2]

M4.(a)   (i)   Propanone evaporates (or similar)

1

Removes water (from the precipitate)
Accept 'removes impurities / excess reagents'.
Accept 'salt insoluble in propanone'.

1

(ii)   Add $NaOH$ / NH_3 / Na_2CO_3

1

No green ppt
Accept 'no visible change'.
Must have correct reagent to score this mark.

1

(iii)   Some salt dissolves (in propanone) **or** some lost in filtration **or** some Fe^{2+} gets oxidised (to Fe^{3+} in air)
Do not accept 'reaction reversible' or 'incomplete reaction' or similar.

1

(iv)   Moles Fe^{2+} = 2.50×10^{-2}
Accept 2.5×10^{-2}

1

M_r of salt = 179.8
Allow 180
Allow if 179.8 or 180 appears in a calculation.

1

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Mass of salt = $179.8 \times 2.5 \times 10^{-2} \times 0.95 = 4.27$ (g)

Correct answer with no working scores this mark only.

Allow range 4.2 to 4.3 (g)

1

(v) 1.67 mol or correct ratio of $5FeC_2O_4 : 3MnO_4^-$

1

(b) $Ca^{2+} + C_2O_4^{2-} \rightarrow CaC_2O_4$

Accept multiples.

1

(c) (Insoluble) calcium ethanedioate coats surface

Allow 'calcium ethanedioate is insoluble'.

Do not allow answers based on ethanedioic acid being a weak acid.

Do not accept 'acid used up' or 'reaction very fast'.

1

(d) Small amount of tea used **or** concentration of the acid in tea is low

Accept 'high temperature decomposes the acid'.

Accept 'calcium ions in milk form a precipitate with the acid'.

Do not accept 'do not drink tea often' or similar.

1

(e) Mass of acid = 180.0 and mass of reagents = 450.0

Accept 180 and 450.

1

(180 / 450 ×100 =) 40.0%

Do not penalise precision.

Correct answer without working scores this mark only.

1

[14]