

M1.(a) For reactions 1 to 3 must show complex ions as reactants and products
Take care to look for possible identification on flow chart

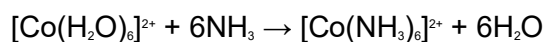
Reaction 1

ammonia solution

1

W is $[\text{Co}(\text{NH}_3)_6]^{2+}$

1



Correct equation scores all 3 marks

1

Reaction 2

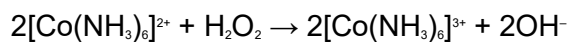
Allow oxygen, Do not allow air

H_2O_2

1

X is $[\text{Co}(\text{NH}_3)_6]^{3+}$

1



Allow $2[\text{Co}(\text{NH}_3)_6]^{2+} + \frac{1}{2}\text{O}_2 + \text{H}_2\text{O} \rightarrow 2[\text{Co}(\text{NH}_3)_6]^{3+} + 2\text{OH}^-$

Correct equations score all 3 marks

1

Reaction 3

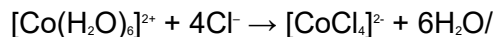
HCl

Do not allow Cl⁻ but mark on

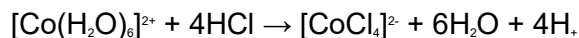
1

Y is $[\text{CoCl}_4]^{2-}$

1



Correct equation scores previous mark



This equation scores all three marks

1

Reaction 4

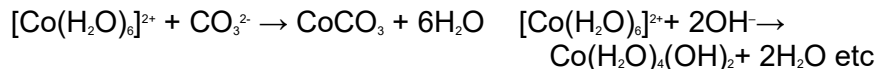
Na_2CO_3 Or NaOH/NH_3

Do not allow CaCO_3 as a reagent but mark on

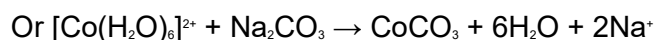
1

Z is CoCO_3 $\text{Co}(\text{OH})_2/\text{Co}(\text{H}_2\text{O})_4(\text{OH})_2$

1

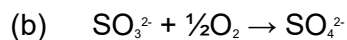


Allow waters to stay co-ordinated to Co. This mark also previous mark



Allow $\text{Co}^{2+} + \text{CO}_3^{2-} \rightarrow \text{CoCO}_3$

1



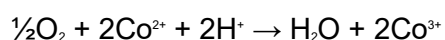
Allow multiples

1

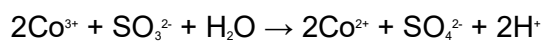
The activation energy is lower (for the catalysed route)

Or Co^{3+} attracts $\text{SO}_3^{2-}/\text{Co}^{2+}$ attracts $\text{SO}_3^{2-}/\text{oppositely charged ions attract}$

1



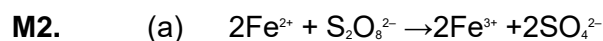
1



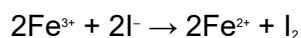
Allow these equations in either order

1

[16]



1



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

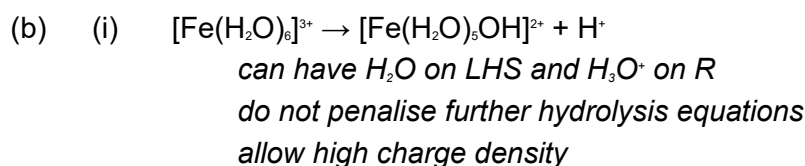
1

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



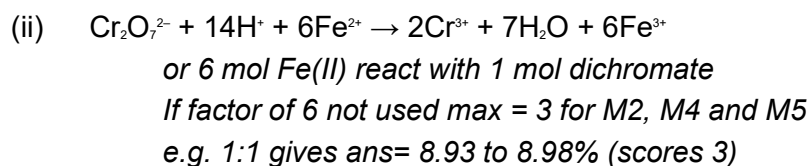
1

Fe^{3+} ion has higher 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



1

$$\text{moles dichromate} = 23.6 \times 0.218/1000 = 5.14 \times 10^{-4}$$

1

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

M3 also scores M1

1

$$\text{mass iron} = 0.00309 \times 55.8 = 0.172$$

Mark is for moles of iron \times 55.8 conseq

Allow use of 56 for iron

1

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

Answer must be to at least 3 sig figures allow 53.6 to 53.9

Mark is for mass of iron \times 100/0.321 conseq

1

(c) brown precipitate / solid

Allow red-brown / orange solid

Not red or yellow solid

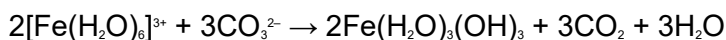
1

bubbles (of gas) / effervescence/ fizz

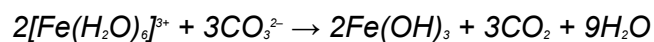
Allow gas evolved / given off

Do not allow just gas or CO₂ or CO₂ gas

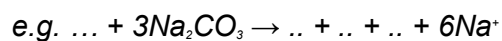
1



Allow



Use of Na₂CO₃



1

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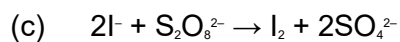
M3. (a) Same phase/state

1

(b) Because only exist in one oxidation state

Allow do not have variable oxidation states

1



*Ignore state symbols
Allow multiples*

1

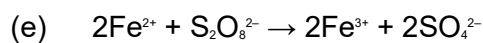
(d) Both (ions) have a negative charge

Or both have the same charge

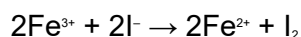
Or (ions) repel each other

*Do not allow both molecules have the same charge
(contradiction)*

1



1



1

Equations can be in any order

Positive and negative (ions)/oppositely charged (ions)

Mark independently

1

(f) Equations 1 and 2 can occur in any order

Allow idea of Fe^{3+} converted to Fe^{2+} then Fe^{2+} converted back to Fe^{3+}

1

[8]

M4. (a) Incomplete (or partially filled) d orbitals/sub-shells

Do not allow d shell

1

(b) Variable oxidation states

1

- (c) (i) $[\text{H}_3\text{N}-\text{Ag}-\text{NH}_3]^+$
Allow $[\text{Cl}-\text{Ag}-\text{Cl}]^+$ or similar Cu(I) ion
Allow compounds in (i), (ii) and (iii) (eg Cl-Be-Cl)
Allow no charge shown, penalise wrong charge(s) 1
- (ii) Cis platin drawn out as square planar
Allow NiX_4^{2-} etc 1
- (iii) $[\text{CuCl}_4]^{2-}$ drawn out as tetrahedral ion
Or $[\text{CoCl}_4]^{2-}$ drawn out 1
- (d) (i) $\text{SO}_2 + 1/2\text{O}_2 \rightarrow \text{SO}_3$
Allow multiples
Allow $\text{SO}_2 + 1/2\text{O}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4$
ignore state symbols 1
- (ii) In a different phase/state (from the reactants) 1
- (iii) $\text{V}_2\text{O}_5 + \text{SO}_2 \rightarrow \text{V}_2\text{O}_4 + \text{SO}_3$
can be in either order 1
- $\text{V}_2\text{O}_4 + 1/2\text{O}_2 \rightarrow \text{V}_2\text{O}_5$
allow multiples 1
- (iv) Surface area is increased 1
- By use of powder or granules or finely divided
Allow suspending/spreading out onto a mesh or support 1
- (e) (i) Forms two or more co-ordinate bonds
Allow more than one co-ordinate bond or donates more than 1 electron pair.
Do not allow "has more than one electron pair"

Allow uses more than one atom to bond (to TM)

1

(ii) Number of product particles > Number of reactant particles

Allow molecules/entities instead of particles

Penalise incorrect numbers (should be 2→5)

1

Disorder increases or entropy increases

(or entropy change is positive)

Allow ΔG must be negative because $\Delta H = 0$ and ΔS is +ve

1

(iii) 6

1

Cyanide strongly bound to Co (by co-ordinate/covalent bond)

1

[16]