

**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

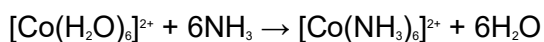
**Reaction 1**

ammonia solution

1

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

1



Correct equation scores all 3 marks

1

**Reaction 2**

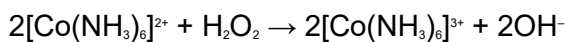
Allow oxygen, Do not allow air

$\text{H}_2\text{O}_2$

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**

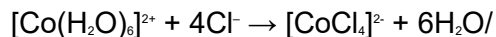
HCl

Do not allow Cl<sup>-</sup> but mark on

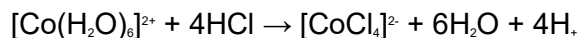
1

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

1



*Correct equation scores previous mark*



*This equation scores all three marks*

1

#### Reaction 4

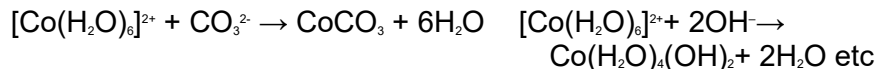
$\text{Na}_2\text{CO}_3$  Or  $\text{NaOH}/\text{NH}_3$

*Do not allow  $\text{CaCO}_3$  as a reagent but mark on*

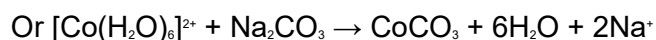
1

Z is  $\text{CoCO}_3$   $\text{Co}(\text{OH})_2/\text{Co}(\text{H}_2\text{O})_4(\text{OH})_2$

1

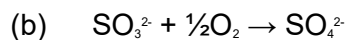


*Allow waters to stay co-ordinated to Co. This mark also previous mark*



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

1



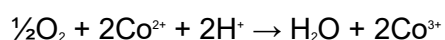
*Allow multiples*

1

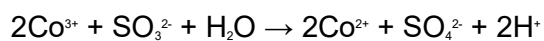
The activation energy is lower (for the catalysed route)

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

1



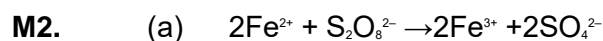
1



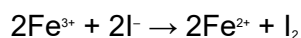
*Allow these equations in either order*

1

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1



1

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

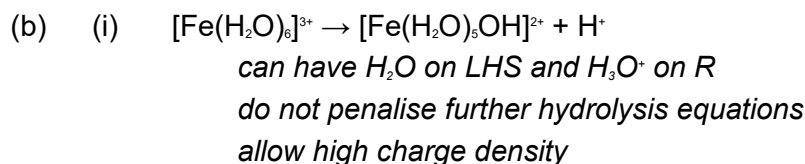
1

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



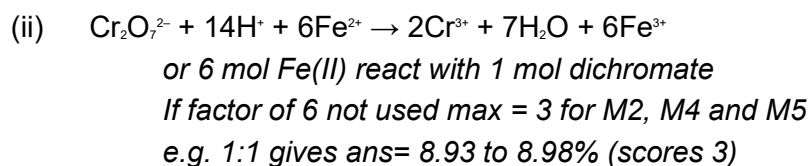
1

$\text{Fe}^{3+}$  ion has higher charge (to size ratio) (than  $\text{Fe}^{2+}$ )

1

increases polarisation of co-ordinated water / attracts O releasing an  $\text{H}^+$  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*

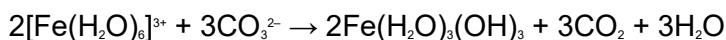
1

bubbles (of gas) / effervescence/ fizz

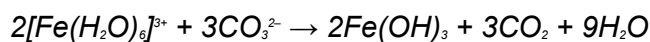
*Allow gas evolved / given off*

*Do not allow just gas or CO<sub>2</sub> or CO<sub>2</sub> gas*

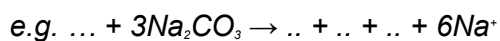
1



*Allow*



*Use of Na<sub>2</sub>CO<sub>3</sub>*



1

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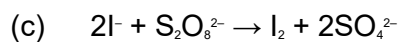
**M3.** (a) Same phase/state

1

(b) Because only exist in one oxidation state

*Allow do not have variable oxidation states*

1



*Ignore state symbols  
Allow multiples*

1

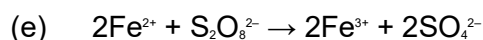
(d) Both (ions) have a negative charge

*Or both have the same charge*

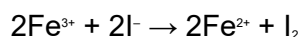
*Or (ions) repel each other*

*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  $\text{Fe}^{3+}$  converted to  $\text{Fe}^{2+}$  then  $\text{Fe}^{2+}$  converted back  
to  $\text{Fe}^{3+}$*

1

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**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  $\text{NiX}_4^{2-}$  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  $\Delta G$  must be negative because  $\Delta H = 0$  and  $\Delta S$  is +ve*

1

(iii) 6

1

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

1

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