

M1.(a) 164.0

Must be 1 decimal place

1

(b) 17.1(%) (= 28.0 × 100 / Qa)

Consequential on their (a)

Ignore precision but must be to at least 2 sig fig.

(i.e. accept 17 or 17.07)

1

(c) (i) Absorption depends on (proportional to) path length / distance travelled through solution

Do not allow size.

1

(ii) To select the colour / frequency / wavelength that is (most strongly) absorbed (by the sample)

Allow the filter is chosen to complement the colour of the solution

1

(iii) Quicker to analyse extracted samples than by titration / uses smaller volumes of solution

1

[5]

M2.(a) $\Delta E = hv$

Allow = hf

1

$$\nu = \Delta E / h = 2.84 \times 10^{-19} / 6.63 \times 10^{-34} = 4.28 \times 10^{14} \text{ s}^{-1} / \text{Hz}$$

Allow $4.3 \times 10^{14} \text{ s}^{-1} / \text{Hz}$

Answer must be in the range:

$$4.28 - 4.30 \times 10^{14}$$

1

(b) (One colour of) light is absorbed (to excite the electron)

If light emitted, CE = 0

1

The remaining colour / frequency / wavelength / energy is transmitted (through the solution)

Allow light reflected is the colour that we see.

1

(c) Bigger

1

Blue light would be absorbed

OR light that has greater energy than red light would be absorbed

OR higher frequency (of light absorbed / blue light) leads to higher ΔE

Can only score M2 if M1 is correct.

1

(d) Any **three** from:

- (Identity of the) metal
- Charge (on the metal) / oxidation state / charge on complex
- (Identity of the) ligands
- Co-ordination number / number of ligands
- Shape

3 max

[9]

M3.(a) Orange dichromate

Allow max 2 for three correct colours not identified to species but in correct order

1

Changes to purple / green / ruby / red-violet / violet Chromium(III)
(Note green complex can be $[\text{Cr}(\text{H}_2\text{O})_5\text{Cl}]^{2+}$ etc)

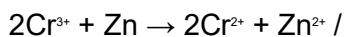
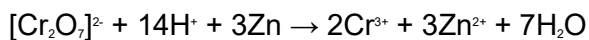
Do not allow green with another colour

1

That changes further to blue Chromium(II)

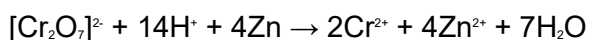
Allow max 1 for two correct colours not identified but in correct order

1



Ignore any further reduction of Cr²⁺

1



Ignore additional steps e.g. formation of CrO₄²⁻

1

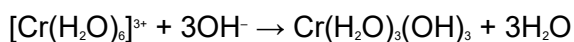
(b) Green precipitate

1

(Dissolves to form a) green solution

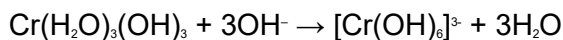
Solution can be implied if 'dissolves' stated

1



Penalise Cr(OH)₃ once only

1



Allow [Cr(H₂O)₆]³⁺ + 6OH⁻ → [Cr(OH)₆]³⁻ + 6H₂O

Allow formation of [Cr(H₂O)₂(OH)₄]⁻ and [Cr(H₂O)(OH)₃]²⁻ in balanced equations

Ignore state symbols, mark independently

1

(c) (ligand) substitution / replacement / exchange

Allow nucleophilic substitution

1

The energy levels/gaps of the d electrons are different (for each complex)
Ignore any reference to emission of light

1

So a different wavelength/frequency/colour/energy of light is absorbed (when d electrons are excited)

OR light is absorbed and a different wavelength/frequency/colour/energy (of light) is transmitted/reflected

1

(d) $E_{O_2} (/ H_2O) > E_{Cr^{3+}} (/ Cr^{2+}) / e.m.f = 1.67 V$
Allow $E_{(cell)} = 1.67$

1

So Cr^{2+} ions are oxidised by oxygen/air
Allow any equation of the form:
 $Cr^{2+} + O_2 \rightarrow Cr^{3+}$

1

With $[Cr(H_2O)_6]^{2+}$ get $CrCO_3$
If named must be chromium(II) carbonate

1

with $[Cr(H_2O)_6]^{3+}$ get $Cr(H_2O)_3(OH)_3 / Cr(OH)_3$
Allow 0 to 3 waters in the complex

1

and CO_2
Can score M3, M4, M5 in equations even if unbalanced

1

Cr(III) differs from Cr(II) because it is acidic / forms H^+ ions

1

because Cr^{3+} ion polarises water

Ignore charge/size ratio and mass/charge

1

[19]

M4.(a) For reactions 1 to 3 must show complex ions as reactants and products
Take care to look for possible identification on flow chart

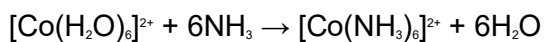
Reaction 1

ammonia solution

1

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

1



Correct equation scores all 3 marks

1

Reaction 2

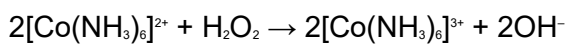
Allow oxygen, Do not allow air

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

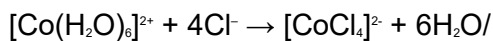
HCl

Do not allow Cl⁻ but mark on

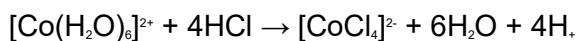
1

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

1



Correct equation scores previous mark



This equation scores all three marks

1

Reaction 4

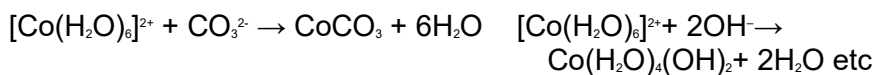
Na_2CO_3 Or NaOH/NH₃

Do not allow CaCO₃ as a reagent but mark on

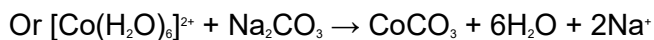
1

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

1

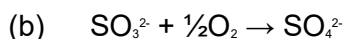


Allow waters to stay co-ordinated to Co. This mark also previous mark



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

1



Allow multiples

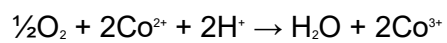
1

The activation energy is lower (for the catalysed route)

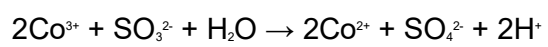
Or Co^{3+} attracts $\text{SO}_3^{2-}/\text{Co}^{2+}$ attracts $\text{SO}_3^{2-}/\text{oppositely charged}$

ions attract

1



1



Allow these equations in either order

1

[16]