

M1.B

[1]

M2.D

[1]

M3.(a) An electron pair on the ligand

1

Is donated from the ligand to the central metal ion

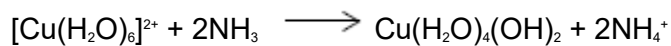
1

(b) Blue precipitate

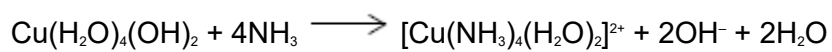
1

Dissolves to give a dark blue solution

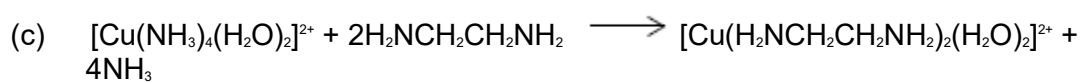
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(d) Cu–N bonds formed have similar enthalpy / energy to Cu–N bonds broken 1

And the same number of bonds broken and made 1

(e) 3 particles form 5 particles / disorder increases because more particles are formed / entropy change is positive 1

Therefore, the free-energy change is negative
M2 can only be awarded if M1 is correct

1
[11]

M4.D

[1]

M5.(a) Co-ordinate / dative / dative covalent / dative co-ordinate
Do not allow covalent alone 1

(b) (lone) pair of electrons on oxygen/O
If co-ordination to O²⁻, CE=0 1

forms co-ordinate bond with Fe / donates electron pair to Fe
'Pair of electrons on O donated to Fe' scores M1 and M2 1

(c) 180° / 180 / 90
Allow any angle between 85 and 95
Do not allow 120 or any other incorrect angle

Ignore units eg °C

1

- (d) (i) 3 : 5 / 5 FeC₂O₄ reacts with 3 MnO₄⁻
Can be equation showing correct ratio

1

- (ii) **M1** Moles of MnO₄⁻ per titration = $22.35 \times 0.0193/1000 = \underline{4.31 \times 10^{-4}}$
Method marks for each of the next steps (no arithmetic error allowed for M2):
Allow $\underline{4.3 \times 10^{-4}}$ (2 sig figs)
Allow other ratios as follows:
eg from given ratio of 7/3

1

M2 moles of FeC₂O₄ = ratio from (d)(i) used correctly $\times 4.31 \times 10^{-4}$
M2 = $7/3 \times 4.31 \times 10^{-4} = 1.006 \times 10^{-3}$

1

M3 moles of FeC₂O₄ in 250 cm³ = M2 ans $\times 10$
M3 = $1.006 \times 10^{-3} \times 10 = 1.006 \times 10^{-2}$

1

M4 Mass of FeC₂O₄.2H₂O = M3 ans $\times 179.8$
M4 = $1.006 \times 10^{-2} \times 179.8 = 1.81 \text{ g}$

1

M5 % of FeC₂O₄.2H₂O = (M4 ans/1.381) $\times 100$
M5 = $1.81 \times 100/1.381 = 131 \%$ (130 to 132)

1

(OR for M4 max moles of FeC₂O₄.2H₂O = $1.381/179.8 (= 7.68 \times 10^{-3})$
for M5 % of FeC₂O₄.2H₂O = (M3 ans/above M4ans) $\times 100$
eg using correct ratio 5/3:
Moles of FeC₂O₄ = $5/3 \times 4.31 \times 10^{-4} = 7.19 \times 10^{-4}$
Moles of FeC₂O₄ in 250 cm³ = $7.19 \times 10^{-4} \times 10 = 7.19 \times 10^{-3}$
Mass of FeC₂O₄.2H₂O = $7.19 \times 10^{-3} \times 179.8 = 1.29 \text{ g}$
% of FeC₂O₄.2H₂O = $1.29 \times 100/1.381 = 93.4$ (allow 92.4 to 94.4)
Note correct answer (92.4 to 94.4) scores 5 marks

Allow consequentially on candidate's ratio
 eg $M2 = 5/2 \times 4.31 \times 10^{-4} = 1.078 \times 10^{-3}$
 $M3 = 1.0078 \times 10^{-3} \times 10 = 1.078 \times 10^{-2}$
 $M4 = 1.078 \times 10^{-2} \times 179.8 = 1.94 \text{ g}$
 $M5 = 1.94 \times 100/1.381 = 140 \% (139 \text{ to } 141)$
 Other ratios give the following final % values
 1:1 gives 56.1% (55.6 to 56.6)
 5:1 gives 281% (278 to 284)
 5:4 gives 70.2% (69.2 to 71.2)

[10]

- M6.** (a) Same phase/state 1
- (b) Because only exist in one oxidation state
Allow do not have variable oxidation states 1
- (c) $2I^- + S_2O_8^{2-} \rightarrow I_2 + 2SO_4^{2-}$
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
- (e) $2Fe^{2+} + S_2O_8^{2-} \rightarrow 2Fe^{3+} + 2SO_4^{2-}$ 1
- $2Fe^{3+} + 2I^- \rightarrow 2Fe^{2+} + I_2$ 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 Fe³⁺ converted to Fe²⁺ then Fe²⁺ converted back to Fe³⁺

1

[8]

M7.(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 Cu²⁺(aq) / [Cu(H₂O)₆]²⁺ is blue

Any correct ion with colour scores M3 and M4

Must show (aq) or ligands OR identified coloured compounde.g. CoCO₃)

1

(b) Tetrahedral

1

[CuCl₄]²⁻ / [CoCl₄]²⁻

Any correct complex

(Note charges must be correct)

1

Square planar 1

$(\text{NH}_3)_2\text{PtCl}_2$
Any correct complex 1

Linear
Do not allow linear planar 1

$[\text{Ag}(\text{NH}_3)_2]^+$
 $[\text{AgCl}_2]^-$ etc 1

(c) (i) $[\text{Ca}(\text{H}_2\text{O})_6]^{2+} + \text{EDTA}^{4-} \rightarrow [\text{CaEDTA}]^{2-} + 6\text{H}_2\text{O}$
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 = $6.25 \times 0.0532 / 1000 = (3.325 \times 10^{-4})$

1

Moles of Ca^{2+} in $1 \text{ dm}^3 = 3.325 \times 10^{-4} \times 1000 / 150 = (2.217 \times 10^{-3})$

Mark is for $M1 \times 1000 / 150$ **OR** $M1 \times 74.1$

If ratio of $\text{Ca}^{2+} : \text{EDTA}$ is wrong or $1000 / 150$ is wrong, CE and can score M1 only

This applies to the alternative

1

Mass of $\text{Ca}(\text{OH})_2 = 2.217 \times 10^{-3} \times 74.1 = 0.164 \text{ g}$

$M1 \times 74.1 \times 1000 / 150$

Answer expressed to 3 sig figs or better

Must give unit to score mark

Allow 0.164 to 0.165

1

[17]

M8. (a) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$

allow $[\text{He}] 2s^2$. or $[\text{Ne}] 3s^2$. or $[\text{Ar}]3d^{10}$

1

d sub-shell / shell / orbitals / sub-level full (or not partially full)

can only score M2 if d^{10} in M1 correct

allow 'full d orbital' if d^{10} in M1

do not allow d block

1

(b) atom or ion or transition metal bonded to / surrounded by one or more ligands

Allow Lewis base instead of ligand

1

by co-ordinate / dative (covalent) bonds / donation of an electron pair

can only score M2 if M1 correct

1

(c) H_2 / hydrogen

do not allow H

1

no lone / spare / non-bonded pair of electrons
only score M2 if M1 correct or give 'H' in M1

1

(d) (i) +2 or 2+ or Pd²⁺ or II or +II or II+ or two or two plus

1

(ii) tetrahedral
these shapes can be in any order

1

square planar
allow phonetic spelling e.g. tetrahydral

1

[9]