TOPIC 15 TEST MS

1. (a) Partially filled/incomplete d sub-shell/orbital/shell

Ignore reference to f orbitals
*Do **not** allow d block*
*Do **not** allow half-filled d orbitals*

1

(b) Has ligand(s)

Allow molecules/ions with lone pairs

1

linked by co-ordinate bonds

Allow dative/donation of lone pair

1

(c) (Blue) light is absorbed (from incident white light)

1

Due to electrons moving to higher levels/electrons excited

Allow d → d transitions

1

Red light (that) remains (is transmitted)/light that remains (transmitted light) is the colour observed

Allow red light reflected

1

(d) (i) Circle round any O^-

List principle

1

Circle round either N

1

(ii) $EDTA^{4-} + [Co(H_2O)_6]^{2+} \rightarrow [CoEDTA]^{2-} + 6H_2O$

Allow missing square brackets
Ignore state symbols

1

(iii) Increase in entropy/ΔS positive

Or increase in disorder

1

Because 2 mol (of particles/molecules/species/entities) form 7 mol

Allow 'increase in number' as stated in words or as shown by any numbers deduced correctly from an incorrect equation
Do not allow increase in ions/atoms

1

(e) (i) Co-ordinate/dative/dative covalent bond
Allow pair of electrons donated by nitrogen/ligand
Do not allow pair of electrons donated from Iron/Fe

1

Covalent bond
Shared electron pair

1

(ii) Transport of oxygen/O_2
Allow any statement that implies oxygen carried (around the body)
Do not allow transport of carbon dioxide (CO_2). This also contradicts the mark (list principle)

1

(iii) Because it bonds to the iron/haemoglobin
Allow blocks site
/CO has greater affinity for haemoglobin
/carboxyhaemoglobin more stable than oxyhaemoglobin

1

Displaces <u>oxygen</u>
Or prevents transport of <u>oxygen</u>
QoL

1

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2. (a) A ligand is an electron pair / lone pair donor
Allow uses lone / electron pair to form a co-ordinate bond

1

A bidentate ligand donates two electron pairs (to a transition metal ion) from different atoms / two atoms (on the same molecule / ion)
QoL

1

(b) $CoCl_4^{2-}$ diagram

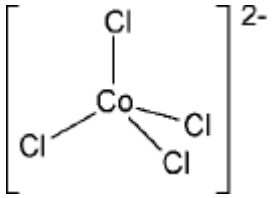
1

Tetrahedral shape

1

109°28’

1



Four chlorines attached to Co with net 2− charge correct
Charge can be placed anywhere, eg on separate formula
Penalise excess charges
Allow 109° to 109.5°

$[Co(NH_3)_6]^{2+}$ diagram

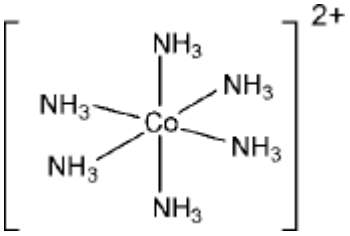
1

Octahedral shape

1

90°

1



Six ammonia / NH_3 molecules attached to Co with 2+ charge correct
Allow 180° if shown clearly on diagram
CE= 0 if wrong complex but mark on if only charge is incorrect

(c) In different complexes the d orbitals / d electrons (of the cobalt) will have different energies / d orbital splitting will be different

1

Light / energy is absorbed causing an electron to be excited

1

Different frequency / wavelength / colour of light will be absorbed / transmitted / reflected

1

(d) 1 mol of H_2O_2 oxidises 2 mol of Co^{2+}
Or $H_2O_2 + 2Co^{2+} \rightarrow 2OH^- + 2Co^{3+}$

1

M_r $CoSO_4.7H_2O$ = 281
If M_r wrong, max 3 for M1, M4, M5

1

Moles Co^{2+} = 9.87 / 281 = 0.03512

1

Moles H_2O_2 = 0.03512 / 2 = 0.01756
M4 is method mark for (M3) / 2 (also scores M1)

1

Volume H_2O_2 = (moles × 1000) / concentration
= 0.01756 × 1000) / 5.00
= 3.51 cm^3 / (3.51 × 10^{-3} dm^3)
Units essential for answer
M5 is method mark for (M4) x 1000 / 5
Allow 3.4 to 3.6 cm^3
If no 2:1 ratio or ratio incorrect Max 3 for M2, M3 & M5
Note: Answer of 7 cm^3 scores 3 for M2, M3, M5 (and any other wrong ratio max 3)
Answer of 16.8 cm^3 scores 3 for M1, M4, M5 (and any other wrong M_r max 3)
Answer of 33.5 cm^3 scores 1 for M5 only (so wrong M_r AND wrong ratio max 1)

1

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3. (a) Negative ions repel one another

1

(b) Positive ions attract negative ions in catalysed process
Allow activation energy decreases.
Allow alternative route with lower E_a
Ignore references to heterogenous catalysis.

1

(c) $S_2O_8^{2-} + 2e^- \longrightarrow 2SO_4^{2-}$
Allow multiples including fractions.
Ignore state symbols.

1

(d) $S_2O_8^{2-} + 2I^- \longrightarrow 2SO_4^{2-} + I_2$
Allow multiples including fractions.
Ignore state symbols.
Allow the correct equation involving I_3^-
$S_2O_8^{2-} + 3I^- \longrightarrow 2SO_4^{2-} + I_3^-$

1

[4]

4. (a) $[Fe(H_2O)_6]^{2+} + 2NH_3 \rightarrow Fe(H_2O)_4(OH)_2 + 2NH_4^+$
Allow equation with OH^- provided equation showing formation of OH^- from NH_3 given

1

Green precipitate

1

$[Fe(H_2O)_6]^{2+} + CO_3^{2-} \rightarrow FeCO_3 + 6H_2O$

1

Green precipitate
effervescence incorrect so loses M4

1

(b) (i) Colourless / (pale) green changes to pink / purple (solution)
Do not allow pale pink to purple

1

Just after the end−point MnO_4^- is in excess / present

1

(ii) $MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+}$

1

Moles $KMnO_4 = 18.7 \times 0.0205 / 1000 = (3.8335 \times 10^{-4})$
Process mark

1

Moles $Fe^{2+} = 5 \times 3.8335 \times 10^{-4} = 1.91675 \times 10^{-3}$
Mark for M2 × 5

1

Moles Fe^{2+} in 250 $cm^3 = 10 \times 1.91675 \times 10^{-3} = 0.0191675$ moles in 50 cm^3
Process mark for moles of iron in titration (M3) × 10

1

Original conc $Fe^{2+} = 0.0191675 \times 1000 / 50 = 0.383$ $\underline{\text{mol dm}^{-3}}$
Answer for moles of iron (M4) × 1000 / 50
Answer must be to at least 2 sig. figs. (0.38)

1

[11]

5. C

[1]

6. D

[1]

7. B

[1]