5.3 TRANSITION METALS TEST MS

1. (a) Zn^{2+} is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$ and
Cu^{2+} is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$ **(1)**;
Allow *Zn^{2+} [Ar]$3d^{10}$ and Cu^{2+} [Ar]$3d^9$*

Copper has at least one ion with an incomplete filled d-orbital (zinc does not) / copper(II) ion has an incomplete set of d electrons (zinc ion does not) / copper(II) ion has an incomplete d sub-shell (zinc ion does not) / ora **(1)** 2

(b) Cu^{2+} compounds are coloured but Zn^{2+} compounds are not **(1)**;
Cu^{2+} compounds may be catalytic but Zn^{2+} compounds are not **(1)** 2

Allow *Cu^{2+} forms complexes but Zn^{2+} does not*
Allow *correct chemistry of Cu^{2+} compared to Zn^{2+} e.g. Cu^{2+} and NaOH gives blue ppt but Zn^{2+} gives white ppt (that redissolves in excess)*

[4]

2. (i) Central ion surrounded by molecules/ions/ligands 1

(ii) Molecule/ion with a lone pair of electrons 1
Able to form a dative covalent or co-ordinate bond / which can be donated 1

[3]

3. (i) $(1s^2 2s^2 2p^6) 3s^2 3p^6 3d^6$ **(1)** 1

(ii) Octahedral shape with some indication of three dimensions **(1)**;

Bond angle 90° **(1)** 2

Allow *use of wedges and dotted lines to indicate three dimensions*

Allow *three dimensions if at least two bond angles of 90o are shown that clearly demonstrate 3D*

If two different bond angles *do not award bond angle mark*

(iii) Green / olive green / dark-green / green-blue ppt **(1)**

Allow *solid instead of precipitate*
Allow solid or precipitate to be awarded from the state symbol in $Fe(OH)_2(s)$

$Fe^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(s)$ **(1)** 2

[5]

4. (i) $[Co(H_2O)_6]^{2+}$ is octahedral
$[CoCl_4]^{2-}$ is tetrahedral (both needed for 1 mark) 1

(ii) pink to blue 1

(iii) Ligand substitution / exchange/displacement 1

[3]

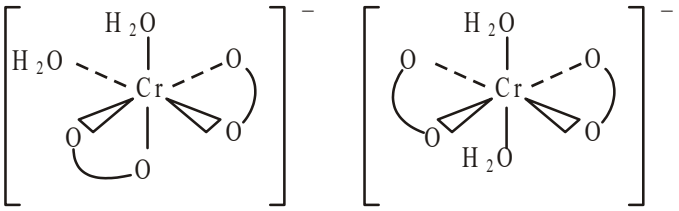
5. (a) (Pale blue solution) to a (light) blue ppt **(1)**;
with excess dark blue solution **(1)** 2

(b) Octahedral shape with clear indication of 3D either by construction lines or wedges etc **(1)**;
90° **(1)** 2

Ignore *mistakes with the ligands question focuses on octahedral and the bond angle*

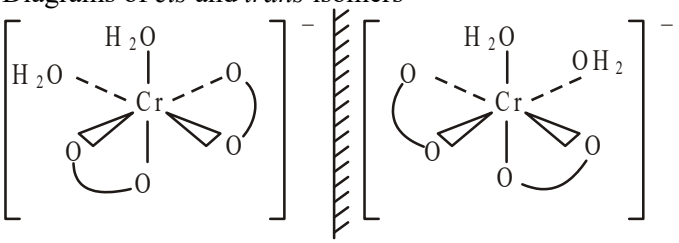
[4]

6. stereoisomers have same structural formula but a
different arrangement in space 1



2

Diagrams of *cis* and *trans* isomers



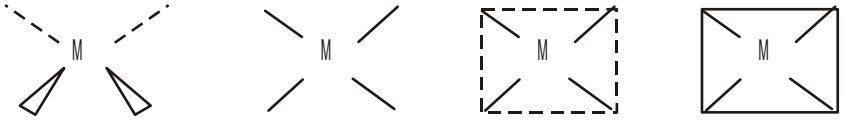
Diagrams showing two optical isomers 2
(If diagrams are wrong / not used give 1 mark for mention of *cis*/*trans* and optical isomerism)
H_2O at 90°/ adjacent in *cis* / 180° / opposite in *trans* (not from diagram) 1
Optical isomers are non-superimposable mirror images 1

Quality of Written Communication:
At least three of the following key words used in context:
non-superimposable, mirror images, optical, *cis*/*trans*, geometric, plane polarised, rotate, chiral, asymmetric 1

[8]

7. (Cis/trans) + Examples (must be 3-d drawings) 2
Correctly labelled as cis and trans (allow this mark if diagrams are planar) 1
Cis has same atoms at 90° + Trans has same atoms at 180° (need reference to bond angles for mark) 1
(Optical) + examples (must be 3-d drawings) 2
Rotate plane polarised light (by same number of degrees) in opposite directions 1
Non-superimposable mirror images 1
NB If use $H_3N\ CH_2\ CH_2\ NH_3$ penalise only once

Any example which show the principle of cis/trans isomerism and optical isomerism are fine but, all diagrams must be 3-d. The shapes shown in the previous question are allowed for octahedral or tetrahedral. For square planar complexes used to illustrate cis/trans isomerism the following illustrations are fine. For optical isomerism, there must be a mirror line and the isomers must be non-superimposable object/mirror images.



QWC – to be awarded for the correct use of scientific terms, to include at least 3 of the following:
Cis & trans, optical, plane, polarised, non-superimposable, mirror images, geometric, bidentate, ligand, octahedral, square planar, tetrahedral 1

[9]

8. $Fe_2O_3 + 3Cl_2 + 10OH^- \rightarrow 2FeO_4^{2-} + 5H_2O + 6Cl^-$ **(2)** 2

Allow *one mark if electrons shown*
Allow *one mark if correct reactants and products but not balanced*

[2]

9. (i) Copper may react with potassium manganate(VII) / iron(III) ions formed in titration may be reduced back to iron(II) ions by the copper **(1)** 1

(ii) MnO_4^- gains electrons and is reduced / Mn oxidation state changes from +7 to +2 so it is reduced **(1)**;
Fe^{2+} loses electrons and is oxidised / Fe oxidation state changes from +2 to +3 so it is oxidised **(1)** 2

(iii) Moles of $MnO_4^- = 4.50 \times 10^{-4}$ **(1)**;
Moles of $Fe^{2+} = 5 \times$ moles $MnO_4^- / 2.25 \times 10^{-3}$ **(1)**;
Mass of Fe = moles of $Fe^{2+} \times 55.8 / 0.1256$ **(1)**;
Percentage = 18.6 % **(1)** 4

Allow *answers that use 56 for A_r of Fe this gives 18.7*
Allow *ecf*

[7]

10. (a) (i) Zinc 1

(ii) Coins + resist corrosion (not rusting) / hard wearing
Or statues + resist corrosion/ attractive patina
Or electrical connections + good conductor
Or musical instruments + attractive / sonorous
Or plumbing fixtures + hard / corrosion resistant 1

(b) (i) Sodium carbonate/sodium hydroxide/other suitable named alkali (accept correct formulae) 1
Do not accept 'alkali' on its own

(ii) Starch 1

(iii) Just before the end point/when solution turns pale straw 1

(c) (i) 0.002 mol 1

(ii) One **(1)** 1

(iii) 0.002 mol 1

(iv) 0.002 mols Cu^{2+} contains 0.002×63.5 g of Cu = 0.127 g 1
250 cm^3 of solution contains 10×0.127 g = 1.27 g 1
% Cu = $1.27/1.65 \times 100 = 77.0\%$ 1
(Allow 76.9-77.0; allow ecf)

[11]