Equilibria, Energetics and Elements
Transition Metals

1. (a) (i) transition element: has at least one ion with a partly filled d-orbital **(1)**
example showing electronic configuration with d orbital
as between $d^1 - d^9$ **(1)**

complex ion: a central metal ion surrounded by ligands
with an example. **(1)**
ligand: molecule/ion with lone pair of electrons capable
of forming coordinate/ dative bonds to a metal ion **(1)** 4

(ii) precipitation: equation **(1)**
colour of precipitate **(1)**

ligand substitution: equation **(1)**
colour of substituted complex **(1)**

redox: equation **(1)**
colour change **(1)**

The candidate clearly links observations to provide evidence
for two reactions discussed. **(1)** 7

(b) complex ions:
octahedral example **(1)**
with 3-D diagram **(1)**

tetrahedral example **(1)**
with 3-D diagram **(1)**

square planar example (see also below) **(1)**
with 3-D diagram **(1)**

stereoisomerism:
cis-trans example, e.g. $Ni(NH_3)_2Cl_2$; platin with 3-D diagram **(1)**
optical example, e.g. $Ni(en)_3^{2+}$ **(1)**
with 3D diagrams **(1)**

The candidate clearly links features on the diagrams with a
characteristic of the stereoisomerism involved **(1)** Max: 9

[20]

2. Oxidation because oxidation state of Hg changes from 0 to +2 so oxidation **(1)**
Reduction because oxidation number of O changes from –1 to –2 **(1)**

Or

Correct identification of all the oxidation numbers **(1)**
Correct identification of oxidation and reduction **(1)** 2

Allow *ecf for the identification of oxidation and reduction from wrong oxidation numbers*

[2]

3. Does not have an incomplete set of d electrons / does not have a partially filled d orbital / does not have a partially filled d sub-shell / ora **(1)** 1

Allow *use of 3d*

[1]

4. (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]

5. (i) $MnO_2 + 4H^+ + 2Fe^{2+} \rightarrow Mn^{2+} + 2H_2O + 2Fe^{3+}$ **(1)** 1

Ignore *state symbols*

(ii) Moles of Fe^{2+} that reacted with $MnO_2 = 0.02 - 0.0123 = 0.0077$ **(1)**

Allow *ecf within question*

Mass of $MnO_2 = 0.00385 \times 86.9 = 0.335$ **(1)**

% purity = 66.4% **(1)**

Allow *66.4 – 66.5*

Alternatively

Moles of MnO_2 in 0.504 = 0.00580

So moles of Fe^{2+} that should react with this is 0.0116 **(1)**

Moles of Fe^{2+} that reacted with $MnO_2 = 0.02 - 0.0123 = 0.0077$ **(1)**

% purity = 66.4% **(1)** 3

[4]

6. (a) (i) +3 1

(ii) Cis and trans forms drawn in 3-D (only award these marks if C has been chosen) 2

(iii) Type of isomerism is cis-trans/geometric 1

(b) (i) (concentrated) hydrochloric acid/sodium chloride/
Other suitable named ionic chloride but *not* just chloride or Cl^- 1

(ii) Ligand substitution / ligand exchange 1

[6]

7. (i) Decolorised / add starch which is decolorised
Allow blue/black → white or brown → white 1
Do not allow colourless

(ii) moles $S_2O_3^{2-} = 23.20 \times 0.100/1000 = 0.00232$ moles 1
$Cu^{2+} \equiv S_2O_3^{2-}$ / moles $Cu^{2+} = 0.00232$ moles 1
But 25 cm^3 of original $= 10 \times 0.00232 = 0.0232$ moles 1
Concentration of original $= 1000 \times 0.0232 / 25$ 1

(iii) Because concentration of Cu^{2+} is less than 1 mol dm^{-3} / less than standard 1
equilibrium moves to left (reducing +ve value of E) 1

[7]

8. (i) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$ **(1)** 1

(ii) Has an incomplete set of d electrons / partially filled d sub-shell / partially filled d orbital **(1)** 1
Allow *partially filled d shell*

[2]

9. (i) Has a (lone) pair of electrons that can be donated / lone pair that can form a dative bond / pair of electrons that can form a coordinate bond **(1)** 1

(ii) 3D diagram of octahedral structure **(1)**;
Bond angle 90° **(1)** 2

Name
octahedral must be present to score two marks
Allow *use of wedges and dotted lines to indicate three dimensions*
Allow *three dimensions if at least two bond angles of 90° are shown that clearly demonstrate 3D*
If two different bond angles *do not award bond angle mark*

[3]

10. (i) Brown / red-brown / foxy-red / rusty / orange ppt (1) 1

Allow *solid instead of precipitate*
Allow *state symbol (s) for precipitate*

(ii) $Fe^{3+}(aq) + 3OH^{-}(aq) \rightarrow Fe(OH)_3(s)$
Correct equation **(1)**
State symbols for the correct formulae even if spectator ions are present **(1)** 2

Allow equations using the hydrated iron(III) ion

[3]

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

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

[2]

12. Correct M_r for Fe_2O_3, 159.6, and of Na_2FeO_4,165.8 (1)
Moles of Fe_2O_3 = 0.00627 **(1)**;
Mass of Na_2FeO_4 = 2.08 **(1)**;
Percentage = 21.6 or 21.7 (%) **(1)** 4

Allow *full marks for correct answer with some working*
Answer ***must*** *have 3 sig figs*
Allow *ecf from wrong moles or wrong mass*

[4]

13. Oxidation state of iron changes from +6 to +3 so is reduction **(1)**

Oxidation state of oxygen changes from –2 to 0 so is oxidation **(1)**

To get the two marks for oxidation states marks any other oxidation state quoted must be correct.
Maximum one mark if any other oxidation number given is wrong

OR

Oxidation state of iron changes from +6 to +3 and
oxidation state of oxygen changes from –2 to 0 **(1)**

Iron is reduced and oxygen is oxidised **(1)** 2

***Allow** ecf from wrong oxidation states*

[2]

14. (i) (Oxidised to) iodine so a brown (solution) formed /
Fe^{3+} formed which is yellow or orange / Fe^{2+} formed which is green **(1)** 1

***Allow** red/brown or orange*

(ii) Nitrogen / N_2 **(1)** 1

Allow any correctly named oxide of nitrogen / correct formulae / HNO_3 etc.

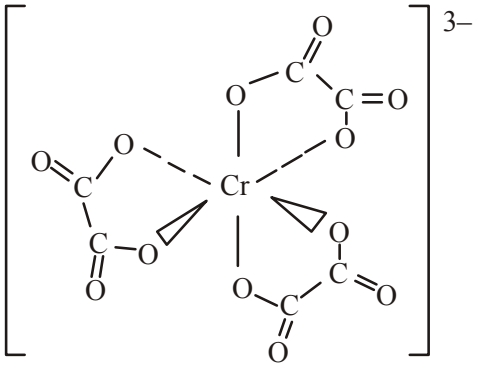
[2]

15. 20 cm^3 of 0.100 mol dm^{-3} VO^{2+} = 0.002 moles 1
0.002 moles VO^{2+} = 0.0004 moles MnO_4^- 1
0.0004 moles MnO_4^- are in 16.0 cm^3 1

[3]

16. (a) Ligand able to donate two lone pairs 1
to form dative covalent / co-ordinate bonds 1

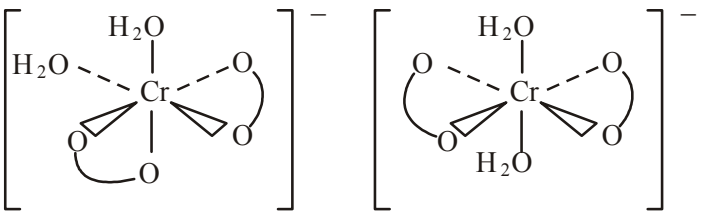
(b)



3-D diagram with three ethanedioate ligands used 1
correct bonding between ligands and Cr^{3+} 1
correct charge on ion (3–) 1
(Accept O ── O as minimum for ethanedioate ion)

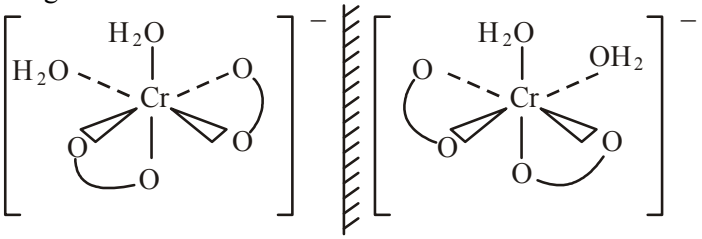
[5]

17. stereoisomers have same <u>structural</u> formula but a
<u>different arrangement in space</u> 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]

18. Add (aqueous) sodium hydroxide which will give a brown/rusty ppt **(1)** 1

Allow solid for precipitate or (s) in equation
Allow Use aqueous thiocyanate ions which gives a (blood) red colouration

[1]

19. (i) $Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+} \rightarrow 2Cr^{3+} + 7H_2O + 6Fe^{3+}$
Correct reactants and products **(1)**;
Correct balancing (electrons cancelled out) **(1)** 2

(ii) Moles of dichromate(VI) = 3.53×10^{-4} **(1)**;
Moles of iron(II) = 2.12×10^{-3} **(1)**:
Moles of impure iron(II) sulphate = 2.36×10^{-3} **(1)**;
Percentage purity = 89.8 / 89.8 – 90.0 **(1)** 4

Allow alternative working out via mass instead of moles e.g. mass of iron in hydrated FeSO4 from percentage composition compared to mass of iron from moles of iron(II).
Allow ecf throughout unless percentage is above 100%

[6]

20. (a) (i) (Blue to) yellow (solution) / (blue to) green (solution) **(1)** 1

(ii) Lone pair on chloride ion **(1)**;
Donated to copper(II) ion **(1)** 2

*Allow dative bond / coordinate bond **(1)***
Allow marks via a diagram that must show lone pairs and the dative bond

(b) (Light) blue precipitate / blue solid **(1)**;
With excess (dark) blue solution **(1)** 2

Not just goes blue

[5]

21. Any three from
Ammonia molecule 1 lone pair (and 3 bond pairs) **(1)**;
Ammonia ligand 4 bond pairs / lone pair is now a bond pair / ligand does not have a lone pair **(1)**;
Lone pairs repel more than bond pairs **(1)**:
In complex equal repulsion between electron pairs **(1)** 3

Not bonds repel / atoms repel

[3]

22. (i) 6 1

(ii) Species with (lone) pair of electrons 1
Capable of being donated / forms a dative covalent
bond / co-ordinate bond to a metal ion. 1
(allow suitable diagram)

[3]

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

(ii) pink to blue 1

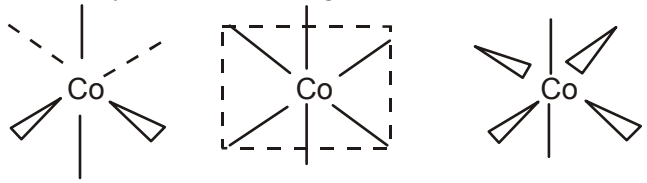
(iii) Ligand substitution / exchange/displacement 1

[3]

24. (a) (i) 1 mark for correct 3-D diagram of cis isomer 1
1 mark for correct 3-D diagram of trans isomer 1

(Allow planar diagrams if two appropriate 90° angles are shown)

Allow any suitable 3-D diagrams. Possibilities to include:

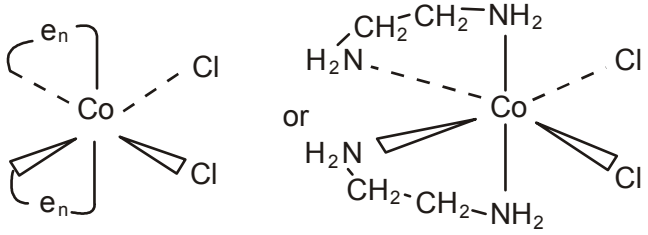


(ii) Geometric / cis – trans 1

(b) 1 mark for using cis isomer 1
1 mark for correct 3-D diagrams which are mirror images of each other. 1

(If all diagrams are drawn as non-3d do not penalise in (b))

Allow any suitable 3-D diagrams such as:



[5]

25. (i) Brown solution/brown precipitate/black solid
Add starch to get blue / black colour 1

(ii) Titration / volumetric analysis 1
using sodium thiosulphate(with starch indicator) 1

(allow from equation)

$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$ 1

1 mol $Cr_2O_7^{2-}$ = 6 mols $S_2O_3^{2-}$ 1

[5]

26. (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]

27. Moles of hydrogen = 3.17×10^{-3} / moles of zinc = 3.17×10^{-3} **(1)**;
Not *3×10^{-3}*

Mass of zinc = 0.207 g / moles of zinc × 65.4 **(1)**;
Not *0.2*

Percentage of copper = 83.2 **(1)** 3
Allow *ecf*
*Final answer must be to **3 or 4 sig figs***
Penalise *significant figures just **once***
Allow *values between 82.9–83.2*

[3]

28. (i) $Cu \rightarrow Cu^{2+} + 2e^{-}$ / $Cu - 2e^{-} \rightarrow Cu^{2+}$ **(1)** 1

(ii) $2Cu + O_2 + 4H^{+} \rightarrow 2Cu^{2+} + 2H_2O$ **(1)** 1

Allow *any correct multiple*
Allow *ecf from (a)(i)*

[2]

29. M_r of $[Cu(CH_3COO)_2]_2.Cu(OH)_2 = 460.5$ **(1)**

Allow *ecf from wrong* M_r

Molar ratio $[Cu(CH_3COO)_2]_2.Cu(OH)_2 : H_2O$ is 0.182 : 0.906 **(1)**
x = 5 **(1)** 3

Not *full marks for 5 with no working out*

[3]

30. Ligand substitution

Suitable example e.g. reaction of thiocyanate ions with hexaaquairon(III)
to give $[Fe(H_2O)_5(CNS)]^{2+}$ **(1)**;
Observations *e.g.* formation of a blood-red colour **(1)**
Suitable equation e.g.
$[Fe(H_2O)_6]^{3+} + CNS^{-} \rightarrow [Fe(H_2O)_5(CNS)]^{2+} + H_2O$ **(1)**

Suitable example can be awarded from an equation
Equations do not need state symbols

Precipitation

Suitable example e.g. reaction between (aqueous) iron(II) chloride
with (aqueous) sodium hydroxide **(1)**;
Observations *e.g.* formation of a green precipitate / formation of a green solid **(1)**
Suitable equation e.g. $Fe^{2+}(aq) + 2OH^{-}(aq) \rightarrow Fe(OH)_2(s)$ **(1)**

Precipitate can be awarded state symbol in equation

Redox

Suitable example e.g. oxidation of iron(II) chloride by chlorine to make iron(III) chloride **(1)**
Observation e.g. green solution becomes yellow / rust solution **(1)**
Suitable equation e.g. $2FeCl_2 + Cl_2 \rightarrow 2FeCl_3$ **(1)**

Other examples could include iron and chlorine to make iron(III) chloride / iron and HCl to make $FeCl_2$ / MnO_4^- and Fe^{2+} to make Fe^{3+}

And QWC

One mark for correct spelling, punctuation and grammar in at least two sentences **(1)** 10

Answer must address the question

[10]

31. (a) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8$ (Do not accept $[Ar]3d^8$) 1

(b) (i) Ring around O^- 1
Ring around N 1
(Accept ring around O of C=O as an alternative to O^-)

(ii) Lone pair (of electrons) / non-bonding pair 1

[4]

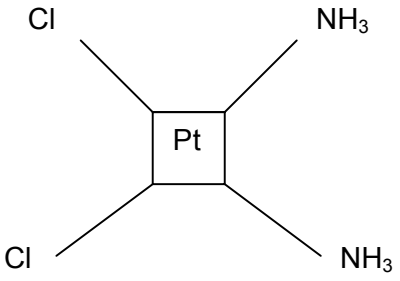
32. (a) (i) Number of dative bonds / co-ordinate bonds formed with the transition metal (Do not accept number of ligands but allow number of lone pairs bonded to….) 1

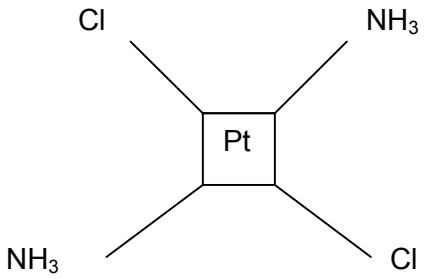
(ii) Square planar 1

(b) (i) Ligand substitution 1

(ii) x = –2 1
y = 0 1

(c) (i) *cis* isomer drawn 1
trans isomer drawn 1
(ignore any charges)





(ii) *cis* / *trans* or geometric 1

(iii) Binds with DNA (not binds with cell) 1
Prevents replication/prevents cell dividing/prevents tumour growth (do not allow kills cell) 1

[10]

33. (a) Moles $V^{2+} = 25.0 \times 0.100 / 1000 = 0.0025$ mols 1
Moles $MnO_4^- = 30.0 \times 0.0500 / 1000 = 0.00150$ mols 1
1 mole of MnO_4^- changes its Oxidation State by 5 to change the Oxidation State of 1.67 moles of V^{2+} 1
Oxidation State of V^{2+} changes by $5 / 1.67 = 3$ 1

(b) $3MnO_4^- + 5V^{2+} + 3H_2O \rightarrow 3Mn^{2+} + 5VO_3^- + 6H^+$
(1 mark for correct species, 1 mark for balanced) 2

[6]

34. (a) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$ **(1)**;
Has an incomplete set of 3d electrons **(1)** 2
Allow *3d orbitals are not completely occupied / incomplete 3d sub-shell*
Allow *has half-filled d orbitals*

(b) **Any two from**
Variable oxidation state / variable valency **(1)**;
Act as catalysts **(1)**;
Form complexes / form complex ions **(1)**;
Form coloured compounds **(1)** 2
Not *high melting point / good thermal and electrical conductors / high density etc*

(c) Iron (II) ions give a green ppt **(1)**;
Iron (III) ions give an orange-rust ppt **(1)** 2

Precipitate must be used once
Allow *solid instead of ppt*

(d) $4Fe^{2+} + O_2 + 4H^+ \rightarrow 4Fe^{3+} + 2H_2O$
Correct reactants and products **(1)**;
Correct balancing **(1)** 2

[8]

35. (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]

36. (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]

37. Water molecule 2 lone pairs (and 2 bond pairs) **(1)**;
Water ligand 1 lone pair and 3 bond pairs / lone pair is now a bond pair / water has one less lone pair when it is a ligand **(1)**;
Lone pairs repel more than bond pairs **(1)** 3

***Not** atoms repel*

[3]

38. (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]

39. (a) Two lone pairs/ able to form two dative covalent / co-ordinate bonds 1

(b) Stereoisomerism – same atoms with same order of bonds but a different spatial arrangement / same structure but different arrangement of atoms 1
Both isomers drawn for cis / trans 2
Both isomers drawn for optical (must be mirror images) 2
(all diagrams to show 3-D arrangement)
Enantiomers/non superimposable mirror images 1
Rotate plane polarised light in opposite direction by same number of degrees (any two for 1 mark) 1

[8]

40. (i) $Cr_2O_7^{2-} + 14H^+ + 6I^- \rightleftharpoons 2Cr^{3+} + 3I_2 + 7H_2O$
All species correct (ignore electrons for this mark) 1
Equation balanced (penalise if electrons not cancelled out) 1

(ii) Brown colour disappears 1
$S_2O_3^{2-}$ reacts with I_2 (to form colourless I^-) 1
Green colour remains due to Cr^{3+} (must say what gives green colour) 1

[5]

41. Transition element

Cu^{2+} $1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$ **(1)**;
Transition elements have one oxidation state that has an incomplete set of 3d electrons / have one ion with a half-filled 3d orbital **(1)**

__Allow__ has at least one half-filled d orbital / partially filled 3d sub-shell

Complex ion

Example of a **copper** complex ion e.g. $[Cu(H_2O)_6]^{2+}$ or $CuCl_4^{2-}$ **(1)**;
Diagram of the copper complex showing three dimensions e.g. use of wedges or dotted lines **(1)**;
Correct bond angle to match the complex / correct name of the shape of the complex **(1)**;

If a copper complex that does not exist is used then first three marks not available
If a correct iron complex is given then example mark cannot be awarded
__Allow__ square planar where appropriate

Ligand is an electron **pair** donor **(1)**;
Copper(II) ion is an electron **pair** acceptor **(1)**;
Dative bond exists between ligand and the copper(II) ion **(1)**

Electron pair donor, electron pair acceptor and dative bond marks can awarded from an appropriate diagram

Properties

Several oxidation states e.g. copper has +1 and +2 or iron has +2 and +3 **(1)**;

Ignore copper has a +3
Ignore iron has a +6 oxidation state

Forms coloured compounds e.g. copper(ii) chloride is green or iron(II) sulphate is pale green **(1)**;
Element or compound has catalytic properties e.g. Iron is a catalyst in the Haber process **(1)** 11

Quality of written communication

Use of technical terms – at least three terms from the following list are used in the correct context

- ligand
- dative bond
- coordinate bond
- tetrahedral
- square planar
- octahedral
- oxidation (state)
- catalyst
- electron pair
- lone pair
- orbital
- sub-shell **(1)** 1

Put a ring around the technical terms

[12]

42. (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

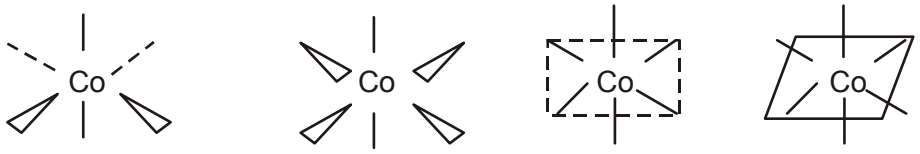
(iv) 0.002 mols Cu^{2+} contains 0.002×63.5 g of Cu = 0.127 g 1
250 cm^3 of solution contains 10×0.127 g = 1.27 g 1
% Cu = $1.27/1.65 \times 100 = 77.0\%$ 1
(Allow 76.9-77.0; allow ecf)

[11]

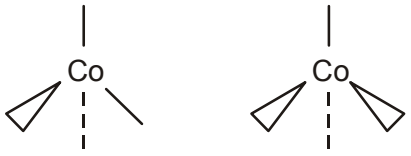
43. (a) Number of coordinate / dative covalent bonds attached
to metal ion / number of lone pairs accepted (not number of ligands) 1

(b) (i) $[Co(H_2O)_6]^{2+}$ is octahedral; $[CoCl_4]^{2-}$ is tetrahedral
Drawings must be 3 dimensional

Acceptable shapes for $[Co(H_2O)_6]^{2+}$ include:



Acceptable shapes for $[CoCl_4]^{2-}$ include



2

(ii) Pink → blue 2

(iii) Add water.
(Allow other suitable suggestions, e.g. add lead nitrate to
precipitate Cl^- as $PbCl_2$) 1

[6]

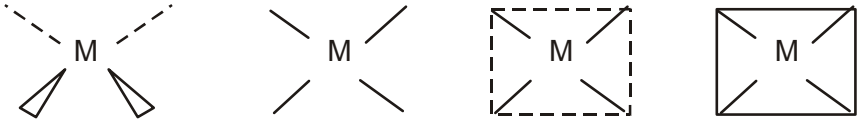
44. (i) Cis platin 1

(ii) Binds to DNA 1
Prevents cell from replicating / cells die 1

[3]

45. (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]