# TRANSITION METAL TEST Answers

**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/$\Delta S$ 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**

**[16]**

**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**

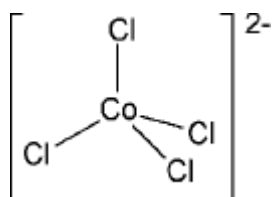(b)    $CoCl_4^{2-}$ diagram

                                                                         **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**
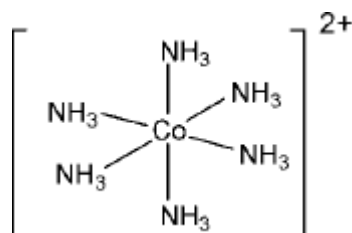


          *Six ammonia / NH$_3$ molecules attached to Co*
          *with 2+ charge correct*
          *Allow 180° if shown clearly on diagram*
          *CE= 0 if wrong complex but mark on if only*
          *charge is incorrect*

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

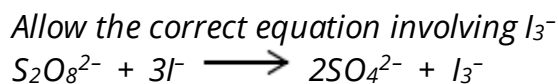                                                                       **1**

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**
                                                                      **[16]**

**3.**    (a)    Negative ions <u>repel</u> one another

                                                                          **1**

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

                                                                          **1**

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

                                                                          **1**

       (d)    $S_2O_8^{2-}$ + 2$I^-$ $\longrightarrow$ 2$SO_4^{2-}$ + $I_2$
              *Allow multiples including fractions.*
              *Ignore state symbols.*

Allow the correct equation involving $I_3^-$

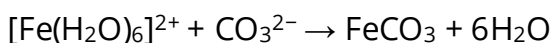$$S_2O_8^{2-} + 3I^- \longrightarrow 2SO_4^{2-} + I_3^-$$

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

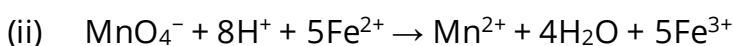Green precipitate

*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 × 0.0205 / 1000 = (3.8335 × 10$^{-4}$)

*Process mark*

1

Moles $Fe^{2+}$ = 5 × 3.8335 × 10$^{-4}$ = 1.91675 × 10$^{-3}$

*Mark for M2 × 5*

1

Moles $Fe^{2+}$ in 250 cm$^3$ = 10 × 1.91675 × 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 × 1000 / 50 = 0.383 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]**