A2CHEM

By @DaK_74

TRANSITION METALS

LATEST: Define transition metal, ligand, complex ion, unidentate, bidentate, hexaden
Lewis acid, Lewis base. State the chemical properties of transition elements. →

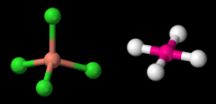
COMPLEXES

Updated 30 January 2015

A complex ion is a central transition metal ion surrounded by ligands via coordinate bonds

The coordination number is the number of coordinate bonds formed by the transition metal ion

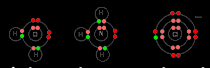
Coordination number 2: linear complexes.



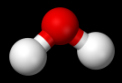
Coordination number 4: tetrahedral and square planar complex

Coordinatio 6: Octahedral

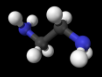
LIGANDS



A ligand is a molecule or ion that forms coordinate bonds with a transition metal ion



Ligands that form 1 coordinate bond: unidentate.
E.g. H_2O, CN^-, Cl^-

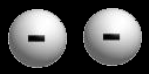


Ligands that form 2 coordinate bonds: bidentate
E.g. en ($NH_2CH_2CH_2NH_2$)

Ligands that form 6 coordinate bonds: hexadentate
E.g. $edta^{4-}$

dentate

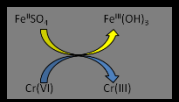
REACTIONS



Ligands are Lewis bases: they are electron pair donors.
Transition metal ions are Lewis acids: they are electron pair acceptors

Redox reactions are reactions where transition metals change their oxidation states

Manganate reduction reaction:
$MnO_4^- + 5e^- + 8H^+ \rightarrow Mn^{2+} + 4H_2O$



Chromate reduction reaction: $Cr_2O_7^{2-} + 6e^- + 14H^+ \rightarrow 2Cr^{3+} + 7H_2O$

Redox reactions used in Fe^{2+} analysis

REDOX CALCULATIONS

CASE STUDIES: Cu, Fe, Cr, Co

CATALYSIS

SUMMARY OF THE WEEK

THE BASICS

Last updated 1 hour ago

Transition metals are d-block elements and at A2 you study mainly the elements found in Period 4 of the Periodic table, titanium to copper.

By definition, transition elements are elements that form at least one ion with a partially filled d-subshell. This explains why scandium and zinc are d-block elements but not transition elements:

Scandium $[Ar]3d^14s^2$ forms a Sc^{3+} ion only: $[Ar]3d^04s^0$
Zinc $[Ar]3d^{10}4s^2$ forms a Zn^{2+} ion only: $[Ar]3d^{10}4s^0$
In both cases, the definition of a transition metal has not been met. (* remember that the 4s electrons are removed first)

All other Period 4 d-block elements form at least one ion with a partially filled d-subshell:

22	23	24	25	26	27	28	29
Ti	V	Cr	Mn	Fe	Co	Ni	Cu
$[Ar]3d^24s^2$	$[Ar]3d^34s^2$	$[Ar]\ 3d^54s^1$	$[Ar]3d^54s^2$	$[Ar]3d^64s^2$	$[Ar]3d^74s^2$	$[Ar]3d^84s^2$	$[Ar]3d^{10}4s^1$
Ti^{3+}	V^{3+}	Cr^{2+}	Mn^{2+}	Fe^{2+}	Co^{2+}	Ni^{2+}	Cu^{2+}
$3d^1$	$3d^2$	$3d^4$	$3d^5$	$3d^6$	$3d^7$	$3d^8$	$3d^9$

Transition metal (chemical) properties:
Most transition metals have compounds with variable oxidation states. At least one of these compounds is coloured. Many transition metals (or their compounds) act as catalysts due the their ability to change oxidation states. Transition metals also form complex ions with ligands.

LATEST: Describe the redox behaviour in transition elements.

PERMANGANATE

Updated 31 January 2015

0.325g of an iron tablet is dissolved in 25cm^3 of acid. 2.5cm^3 of the resulting solution was titrated with 0.002moldm^{-3} potassium permanganate solution, and 12.10cm^3 of the permanganate solution was used. Find the % mass of iron in the tablet.

MnO_4^- purple

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

Moles $MnO_4^- = 0.002 \times 12.10/1000 = 2.42\times10^{-5}$

Moles Fe^{2+} in 2.5cm^3 $= 5\times 2.42\times10^{-5} = 1.21\times10^{-4}$

Moles Fe^{2+} in 25cm^3 $= 10 \times 1.21\times10^{-4} = 1.21\times10^{-3}$

Mn^{2+} Pale pink

Mass iron = moles x molar mass = $1.21\times10^{-3} \times 55.8 = 0.0675$g % mass = 0.0675/0.325 = 0.2077 = 20.77%

DICHROMATE

A solution containing aqueous $Cr_2O_7^{2-}$ ions was titrated against 25cm^3 of 0.05moldm^{-3} Fe^{2+} ions in acid solution. The volume of the dichromate solution required to reach the endpoint was 12.30cm^3. What was the concentration of the dichromate solution?

$Cr_2O_7^{2-}$ orange

$6Fe^{2+} + Cr_2O_7^{2-} + 14H^+ \rightarrow 6Fe^{3+} + 14H_2O + 2Cr^{3+}$

Moles $Fe^{2+} = 0.05 \times 25/1000 = 0.00125$

Moles $Cr_2O_7^{2-} = 0.00125/6 = 2.083 \times 10^{-4}$

Cr^{3+} green

Concentration = moles x 1000/volume = $2.083\times10^{-4} \times 1000/12.30 = 0.017$moldm^{-3}

THIOSULFATE

0.6g of bronze is dissolved in nitric acid to form a solution that contains Cu^{2+} ions. After neutralisation, the solution is reacted with iodide ions to form iodine. The iodine is titrated with 0.15moldm^{-3} sodium thiosulfate. 22.30cm^3 are required. What is the % of copper in the bronze?

I_2

$2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$ and

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

Moles $S_2O_3^{2-} = 0.15 \times 22.30/1000 = 0.0033$

I^-

Moles I_2 = moles $S_2O_3^{2-}/2$; moles Cu^{2+} = moles $I_2 \times 2$; therefore moles Cu^{2+} = moles $S_2O_3^{2-} = 0.0033$

Mass copper = moles x molar mass = 0.0033 x 63.5 = 0.21g % of copper in bronze = 0.21/0.6 = 0.354 = 35.4%

OTHER HALF EQUATIONS: $C_2O_4 \rightarrow 2CO_2 + 2H^+ + 2e^-$; $H_2O_2 \rightarrow O_2 + 2H^+ + 2e^-$

CASE STUDIES: Cu, Fe, Cr, Co

CATALYSIS & COLORIMETRY

SUMMARY OF THE WEEK

AN OVERVIEW

Last updated 1 hour ago

Transition metals have variable oxidation states and each oxidation state has a characteristic colour. This allows chemists to use redox titrations in analysis.

The most important redox reactions at A2 are those that take place between permanganate ions and iron(II) ions, dichromate ions and iron(II) ions, copper(II), iodide and thiosulfate ions.

<u>Permanganate titrations:</u>

MnO_4^- is reduced by Fe^{2+} under acidic conditions (H_2SO_4 rather than HCl as otherwise Cl_2 would be released as the HCl reacts with the oxidising agent MnO_4^-). The reaction is self-indicating as the purple MnO_4^- is reacted to pink Mn^{2+} ions which means the colourless Fe^{2+} solution changes to pale pink at the end point.

<u>Dichromate titration:</u>

$Cr_2O_7^{2-}$ is reduced by Fe^{2+} under acidic conditions (H_2SO_4 again for the same reasons as above). Cr^{3+} ions are produced.

<u>Thiosulfate titration:</u>

Firstly, iodide ions are added to the ion under investigation (i.e. Cu^{2+}). Iodine and a white CuI precipitate are produced. The mixture of I_2 and CuI is then titrated against $S_2O_3^{2-}$. I_2 is reduced to I^- and the colour changes from brown to pale yellow. Starch is added and a black colour forms due to the remaining I_2. When the colour disappears, the endpoint is reached.

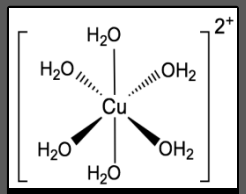
LATEST: State the colours and shapes of common copper complexes. Describe copper ligand substitution reactions. Define Lewis acid and Lewis base.

COLOURS

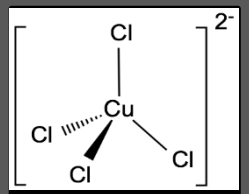
Updated 31 January 2015

Hexaaquacopper(II) ion	Tetrachloro-cuprate(II) ion	Tetraamine diaqua copper(II) ion	Tetraaqua dihydroxy copper(II)	Green
$[Cu(H_2O_6)]^{2+}_{(aq)}$	$[CuCl_4]^{2-}_{(aq)}$	$[Cu(NH_3)_4(H_2O)_2]^{2+}$	$[Cu(OH)_2(H_2O)_4]_{(s)}$	$CuCO_{3\ (s)}$
Pale blue solution	Yellow solution	Deep blue solution	Pale blue gelantinous Precipitate	

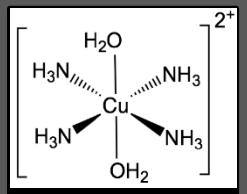
COMPLEX SHAPES



Octahedral



Tetrahedral



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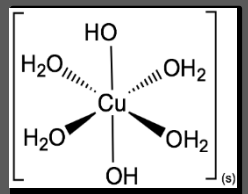

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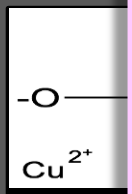

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REACTIONS

Acid-base reaction	Ligand substitution with conc HCl	Ligand substitution with aqueous NH_3	Precipitation reaction
$Cu^{2+} + 6H_2O \rightarrow [Cu(H_2O)_6]^{2+}$	$[Cu(H_2O)_6]^{2+} + 4Cl^- \rightarrow [CuCl_4]^{2-} + H_2O$	$[Cu(H_2O)_6]^{2+} + 4NH_3 \rightarrow [Cu(H_2O)_2(NH_3)_4]^{2+} + 4H_2O$	$[Cu(H_2O)_6]^{2+} + 2OH^- \rightarrow [Cu(OH)_2(H_2O)_4]_{(s)}$
Cu^{2+} accepts electron pairs = Lewis acid	Copper changes from six-coordinate to four-coordinate	Note: excess NH_3 required	The reaction happens in stages, with one H_2O being deprotonated at a time. The same reaction takes place when small amounts of NH_3 are added due to: $2NH_3 + H_2O \rightarrow 2NH_4^+ + 2OH^-$

CASE STUDIES: Fe, Cr, Co

CATALYSIS & COLORIMETRY

ADDITIONAL KNOWLEDGE

SUMMARY OF THE WEEK

CASE STUDY 1: COPPER

Last updated 1 hour ago

Electron configuration: Cu $4s^1$ $3d^{10}$

Common oxidation states: Cu(I) $3d^{10}$ | Cu(II) $3d^9$

Other possible oxidation states: Cu(III) Cu(IV)

Acid – Base theories:

A *Brønsted-Lowry acid* is a proton donor. A *Brønsted-Lowry base* is a proton acceptor.

A *Lewis acid* is an electron pair acceptor. A *Lewis base* is an electron pair donor. This means, all transition metal ions act as Lewis acids and all ligands act as Lewis bases. A ligand substitution reaction is therefore an extension of acid-base reactions.

Using the acid-base theory to describe the reaction of Cu^{2+} ions, where the aqua complex acts an acid by donating a proton to an OH^- ion or H_2O (called hydrolysis):

$[Cu(H_2O)_6]^{2+}_{(aq)} + OH^- \rightarrow [Cu(H_2O)_5OH]^+_{(aq)} + H_2O$

$[Cu(H_2O)_5OH]^+_{(aq)} + OH^- \rightarrow [Cu(H_2O)_4(OH)_2]_{(s)}$

……

$[Cu(H_2O)_6]^{2+}_{(aq)} + H_2O \rightleftharpoons [Cu(H_2O)_5OH]^+_{(aq)} + H_3O^+$

……

When the base CO_3^{2-} is added, $CuCO_{3(s)}$ is formed.

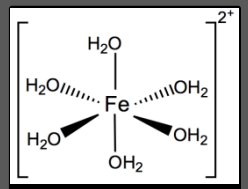
LATEST: State the colours and shapes of common iron complexes. Explain why Fe^{3+} aqua ions are more acidic than Fe^{2+} aqua ions. Know the use of Fe as a catalyst →

COLOURS

Updated 1 February 2015

$[Fe(H_2O_6)]^{2+}_{(aq)}$	$[Fe(H_2O_6)]^{3+}_{(aq)}$	$[Fe(H_2O)_4(OH)_2]_{(s)}$	$[Fe(H_2O)_3(OH)_3]_{(s)}$	$FeCO_{3\ (s)}$
Pale green solution	Purple/yellow/brown solution	Green gelatinous precipitate	Brown gelatinous precipitate	Green

COMPLEX SHAPES



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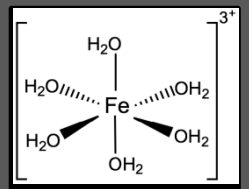

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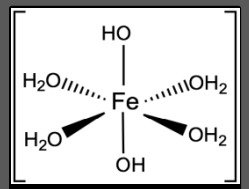

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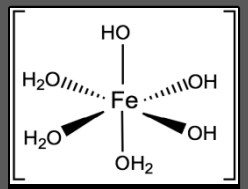

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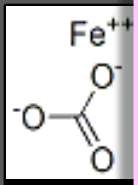

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REACTIONS

Acid-base reaction

$Fe^{2+/3+} + 6H_2O \rightarrow [Fe(H_2O)_6]^{2+/3+}$

$Fe^{2+/3+}$ accept electron pairs = Lewis acid

Precipitation reaction

$[Fe(H_2O)_6]^{2+} + 2OH^- \rightarrow [Fe(OH)_2(H_2O)_4]_{(s)}$; this is soon oxidised to: $[Fe(OH)_3(H_2O)_3]_{(s)}$

The precipitation reaction happens in stages, with one H_2O ligand being deprotonated at a time.

The same precipitates are formed when **NH_3** solution is added; the precipitates this time do not dissolve in excess NH_3.

With aqueous **CO_3^{2-}**, the Fe^{2+} aqua complex forms a green precipitate of $FeCO_3$.

The Fe^{3+} aqua complex reacts differently due to its acidic property:

$2[Fe(H_2O_6)]^{3+}_{(aq)} + 3CO_3^{2-}{}_{(aq)} \rightarrow 2[Fe(OH)_3(H_2O)_3]_{(s)} + 3CO_{2(g)} + 3H_2O_{(l)}$

CASE STUDIES: Cr, Co

CATALYSIS & COLORIMETRY

ADDITIONAL KNOWLEDGE

SUMMARY OF THE WEEK

CASE STUDY 2: IRON

Last updated 1 hour ago

Electron configuration: Fe $4s^2$ $3d^6$

Common oxidation states: Fe(II) $3d^6$; Fe(III) $3d^5$

Other possible oxidation states: Fe(I), Fe(IV), Fe(V), Fe(VI)

Catalysis

Iron is the catalyst used in the Haber Process:

$N_2 + 3H_2 \rightleftharpoons 2NH_3$

Acid-Base Theory:

When an Iron(II) compound is dissolved in water, the complex ion $[Fe(H_2O)_6)]^{2+}$ is formed. The Fe^{2+} ion acts as a Lewis acid by accepting an electron pair from each H_2O ligand, or Lewis base. The same happens when an Iron(III) salt is dissolved in water; the complex ion $[Fe(H_2O)_6]^{3+}$ is formed.

Comparing the acidity of Fe^{2+} and Fe^{3+} aqua ions:

Fe^{2+} solutions are less acidic than Fe^{3+} solutions. This is due to the Fe^{3+} ion being smaller and more positively charged than the Fe^{2+} ion (The Fe^{3+} ion has a higher charge/size ratio). The Fe^{3+} ion strongly attracts electrons from the O atom in one of the H_2O ligands which weakens the O-H bond in the ligand. The O-H bond breaks and an H^+ ion is released:

$[Fe(H_2O)_6]^{3+} + H_2O \rightleftharpoons Fe(H_2O)_5(OH)]^{2+} + H_3O^+$

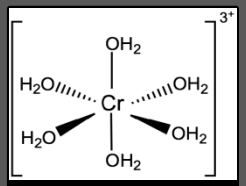
LATEST: State the colours, shapes and reactions of common chromium complexes.

COLOURS

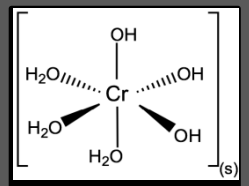
Updated 1 February 2015

$[Cr(H_2O_6)]^{3+}_{(aq)}$ Ruby solution	$[Cr(H_2O)_3(OH)_3]_{(s)}$ Green precipitate	$[Cr(OH)_6]^{3-}_{(aq)}$ Green solution	$[Cr(NH_3)_6]^{3+}_{(aq)}$ Purple solution	CrO_4^{2-} Yellow sol $Cr_2O_7^{2-}$ Orange so

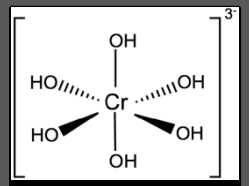
COMPLEX SHAPES



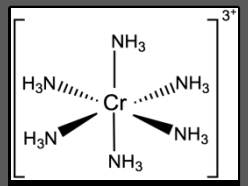
Octahedral



Octahedral



Octahedral



Octahedral

CrO_4^{2-} is stable in alkaline conditions ⇌ $Cr_2O_7^{2-}$ is stable in acidic conditions

REACTIONS

Amphoteric hydroxide

$[Cr(OH)_3(H_2O)_3]$ is an amphoteric hydroxide. It can act as an acid, donating H^+ ions:
$[Cr(OH)_3(H_2O)_3] + 3OH^- \rightarrow [Cr(OH)_6]^{3-} + 3H_2O$
or as a base, accepting H^+ ions:
$[Cr(OH)_3(H_2O)_3] + 3H_3O^+ \rightarrow [Cr(H_2O)_6]^{3+} + 3H_2O$

Precipitation reaction

$[Cr(H_2O)_6]^{3+} + 3OH^- \rightarrow [Cr(OH)_3(H_2O)_3]_{(s)}$
The same precipitate is formed when **NH_3** solution is added; the precipitate dissolves in excess NH_3 to form $[Cr(OH)_6]^{3-}_{(aq)}$.
With aqueous **CO_3^{2-}**, the Cr^{3+} aqua complex forms a green precipitate of $[Cr(OH)_3(H_2O)_3]_{(s)}$ and CO_2 gas is released:
$2[Cr(H_2O)_6]^{3+}_{(aq)} + 3CO_3^{2-}_{(aq)} \rightarrow 2[Cr(OH)_3(H_2O)_3]_{(s)} + 3CO_{2(g)} + 3H_2O_{(l)}$

CASE STUDIES: Co

CATALYSIS & COLORIMETRY

ADDITIONAL KNOWLEDGE

SUMMARY OF THE WEEK

CASE STUDY 3: CHROMIUM

Last updated 1 hour ago

Electron configuration: Cr $4s^1$ $3d^5$

2electrons in the 4s orbital repel. As the energies of the 3d and 4s orbitals are close together, one of the 4s electrons is moved to the empty 3d orbital to form a $4s^1 3d^5$ configuration instead of $4s^2 3d^4$.

Common oxidation states: Cr(III) $3d^3$ | Cr(VI) CrO_4^{2-} | Cr(VI) $Cr_2O_7^{2-}$

Other common oxidation states: Cr(II) $CrCl_2$

Cr(III) is more stable than Cr(II) which is soon oxidised by oxygen to Cr(III). To prepare Cr(II), zinc is added to a solution of acidified $Cr_2O_7^{2-}$. $Cr_2O_7^{2-}$ is reduced first to Cr^{3+} and then to Cr^{2+}. H_2 is produced as a by-product which is used to exclude any air:

$Cr_2O_7^{2-} + 14H^+ + 3Zn \rightarrow 2Cr^{3+} + 7H_2O + 3Zn^{2+}$
$2Cr^{3+} + Zn \rightarrow 2Cr^{2+} + Zn^{2+}$
$(Zn + 2H^+ \rightarrow H_2 + Zn^{2+})$

Chromium cycle: (from $[Cr(H_2O)_6]^{3+}$ to $Cr_2O_7^{2-}$ and back):

$[Cr(H_2O)_6]^{3+}_{(aq)} + 3OH^- \rightarrow [Cr(OH)_3(H_2O)_3]_{(s)} + 3H_2O$
$[Cr(OH)_3(H_2O)_3]_{(s)} + 3OH^- \rightarrow [Cr(OH)_6]^{3-}_{(aq)} + 3H_2O$

$2[Cr(OH)_6]^{3-}_{(aq)} + 3H_2O_2 \rightarrow 2CrO_4^{2-}_{(aq)} + 2OH^- + 8H_2O$

$2CrO_4^{2-}_{(aq)} + 2H^+ \rightleftharpoons Cr_2O_7^{2-}_{(aq)} + H_2O$
$Cr_2O_7^{2-} + 14H^+ + 3Zn \rightarrow 2Cr^{3+} + 7H_2O + 3Zn^{2+}$

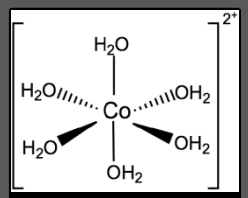
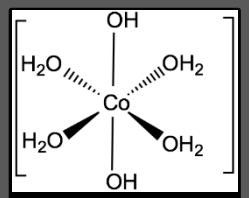
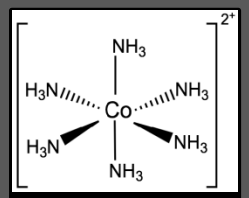
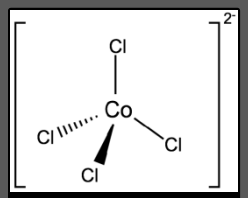
LATEST: State the colours, shapes and reactions of common cobalt complexes.

COLOURS

Updated 1 February 2015

$[Co(H_2O_6]^{2+}_{(aq)}$	$[Co(H_2O)_4(OH)_2]_{(s)}$	$[Co(NH_3)_6]^{2+}_{(aq)}$	$[CoCl_4]^{2-}_{(aq)}$	$CoCO_3$
Pink solution	Green-Blue precipitate	Straw-yellow/brown solution	Blue solution	Pink precipitate

COMPLEX SHAPES

				Formed when CO_3^{2-} solution is added to $[Co(H_2O)_6]^{2+}$ solution
Octahedral	Octahedral	Octahedral	Tetrahedral	

REACTIONS

Colour changes

$[Co(NH_3)_6]^{2+}$ is straw-yellow/brown in colour.
$[Co(NH_3)_6]^{3+}$ is red-brown in colour.
The colour of a complex depends on the oxidation state of the central metal ion and the ligands bonded to the central metal ion. In this case, the colour change is due to the change in oxidation state of cobalt.

Precipitation reaction

$[Co(H_2O)_6]^{2+} + 2OH^- \rightarrow [Co(OH)_2(H_2O)_4]_{(s)}$:
The precipitate dissolves in excess hydroxide to form a deep blue solution of $[Co(OH)_4]^{2-}$ and $[Co(OH)_6]^{4-}$
When NH_3 is added to the aqua ion, the same $[Co(OH)_2(H_2O)_4]_{(s)}$ precipitate is formed. With excess **NH_3** the precipitate dissolves and straw yellow/brown $[Co(NH_3)_6]^{2+}$ is formed.

CATALYSIS & COLORIMETRY

ADDITIONAL KNOWLEDGE

EXAM QUESTIONS

SUMMARY OF THE WEEK

CASE STUDY 4: COBALT

Last updated 1 hour ago

Electron configuration: Co $4s^2$ $3d^7$

Common oxidation states: Co(II) $3d^7$; Co(III) $3d^6$

Other possible oxidation states: Co(I), Co(IV), Co(V)

Oxidation of Co(II) to Co(III):

Co(II) can be oxidised to Co(III) in alkaline solutions:

$2[Co(OH)_6]^{4-} + H_2O_2 \rightarrow 2[Co(OH)_6]^{3-} + 2OH^-$

Oxidation of Co(II) to Co(III) can also be achieved by adding excess ammonia to an aqueous Co(II) solution that is exposed to air:

(remember that first a hydroxide precipitate is formed due to the presence of OH^- ions: $2NH_3 + H_2O \rightarrow 2NH_4^+ + 2OH^-$)

$[Co(H_2O)_6]^{2+}_{(aq)} + 2OH^- \rightarrow [Co(H_2O)_4(OH)_2]_{(s)} + 2H_2O$
$[Co(H_2O)_4(OH)_2]_{(s)} + 6NH_3 \rightarrow [Co(NH_3)_6]^{2+} + 2OH^- + 4H_2O$
$4[Co(NH_3)_6]^{2+} + O_2 + 2H_2O \rightarrow 4[Co(NH_3)_6]^{3+} + 4OH^-$

LATEST: Give examples of heterogeneous and homogeneous catalysts and describe autocatalysis. Explain why transition metal compounds are coloured. Describe colorimetry→

COLOURED IONS

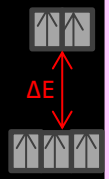
Updated 1 February 2015

The colour of transition metal compounds is due to d-orbital splitting.

In an isolated d-block element, the 5 d-orbitals have the same energy.

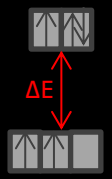
As soon as ligands bond to the central ion, the d-orbitals are 'split':

The gap between the orbitals depends on the type of ligand, number of coordinate bonds and oxidation state of the central ion.



D-ORBITAL SPLITTING

Electrons absorb energy from the visible region of the spectrum to move to a higher energy d-orbital. We observe the transmitted colour. E.g. a solution appears red because it absorbs light in the blue region.



The energy gap and the frequency of the light absorbed are related according to the equation:

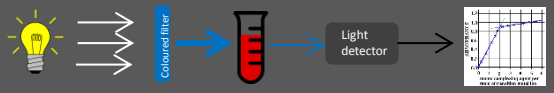
$\Delta E = h\nu$.

h= Planck's constant; v= frequency

Examples:

VO_2^+ = yellow
VO^{2+} = Blue
V^{3+} = green
V^{2+} = violet

COLORIMETRY



Colorimetry

This is a method used to determine the formula of a complex ion by finding the central ion to ligand ratio.

Solutions containing the metal ion and ligand are mixed in varying proportions. When mixed in the same ratio as in the complex, the solution will absorb most light.

The method

The colorimeter measures the intensity of the colour in the liquid by passing filtered light through the sample. The filter is of the colour that is absorbed by the solution.

The maximum absorbance is taken from the graph. The molar ratio of the central ion and ligands can then be calculated from the volumes and concentrations of both solutions at the maximum absorbance.

ADDITIONAL KNOWLEDGE

EXAM QUESTIONS

TEST

SUMMARY OF THE WEEK

CATALYSIS

Last updated 1 hour ago

Heterogeneous catalysts

A catalyst that is in a different phase from the reactants. (3 steps: Adsorption, Reaction, Desorption). Catalysts are usually spread over a ceramic support surface to reduce the cost and maximise the surface area. Catalysts can become coated with impurities and are 'poisoned' as a result. This reduces the efficiency of the catalysts.

Examples of heterogeneous catalysts:

Fe in the Haber process $N_2 + 3H_2 \rightleftharpoons 2NH_3$

V_2O_5 in the Contact process $SO_2 + ½\ O_2 \rightleftharpoons SO_3$
Step 1: $V_2O_5 + SO_2 \rightarrow V_2O_4 + SO_3$
Step 2: $V_2O_4 + ½\ O_2 \rightarrow V_2O_5$

Ni in hydrogenation of oils (adding H_2 to a C=C bond)

Cr_2O_3 in production of methanol from CO and H_2
Step1: $CH_4 + H_2O \rightarrow CO + 3H_2$
Step 2: $CO + 2H_2 \rightarrow CH_3OH$

Homogeneous catalysts:

A catalyst that is in the same phase as the reactants. The catalysts reacts with the reactants to form an intermediate state with a lower activation energy. The catalyst is regenerated at the end of the reaction:

$S_2O_8^{2-} + \underline{2Fe^{2+}} \rightarrow 2SO_4^{2-} + \underline{2Fe^{3+}}$; $2Fe^{3+} + 2I^- \rightarrow \underline{2Fe^{2+}} + I_2$

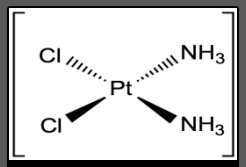
Autocatalysis: $2MnO_4^- + 16H^+ + 5C_2O_4^{2-} \rightarrow 2Mn^{2+} + 8H_2O + 10CO_2$
$4Mn^{2+} + MnO_4^- + 8H^+ \rightarrow 5Mn^{3+} + 4H_2O$
$2Mn^{3+} + C_2O_4^{2-} \rightarrow Mn^{2+} + 2CO_2$

The reaction is slow at the start (both ions are negative) but speeds up once the catalyst Mn^{2+} is produced during the reaction.

LATEST: Describe chelation. Give examples of square planar complex ions. Describe action of cis-platin on cancer cells. Describe the amphoteric nature of $Al(OH)_3$.

STEREOISOMERISM

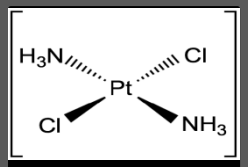
Updated 1 February 2015



Cis platin (square planar)

Used as an anti-cancer drug. Cis-platin binds to the DNA of cancer cells and stops cell replication.

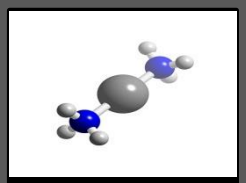
Unfortunately, cis-platin also binds to normal cells and prevents cell replication.



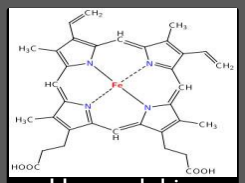
Trans platin

Trans platin does not show anticancer properties

ADDITONAL COMPLEXES

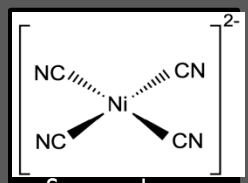


Linear $[Ag(NH_3)_2]^+$



Haemoglobin complex

Fe^{2+} at the centre of the haemoglobin comlex. O_2 acts as a ligand.



Square planar $[Ni(CN)_4]^{2-}$

$[Pt(en)_2]^{2+}$ is another square planar complex

ALUMINIUM COMPOUNDS

Amphoteric hydroxide

Although aluminium is not a transition metal, its hydroxide also acts as an acid and a base:
$Al(H_2O)_3(OH)_3 + 3H^+ \rightarrow [Al(H_2O)_6]^{3+}$
$Al(H_2O)_3(OH)_3 + OH^- \rightarrow [Al(OH)_4]^- + 3H_2O$
$Al(H_2O)_3(OH)_3$ is a white precipitate; $[Al(OH)_4]^-$ forms a colourless solution.

Reactions of $[Al(H_2O)_6]^{3+}$

With little OH^-, $[Al(OH)_3(H_2O)_2]_{(s)}$ is formed. It dissolves in excess OH^- to form a colourless $[Al(OH)_4]^-_{(aq)}$solution. Addition of NH_3 (little or excess) produces the same white hydroxide precipitate. Adding CO_3^{2-} solution, produces CO_2 and the white hydroxide precipitate:
$2[Al(H_2O)_6]^{3+} + 3CO_3^{2-} \rightarrow 2[Al(OH)_3(H_2O)_3] + 3CO_2 + 3H_2O$

EXAM QUESTIONS

TEST

EXAM

SUMMARY OF THE WEEK

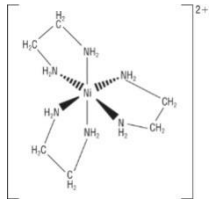
CHELATION

Last updated 1 hour ago

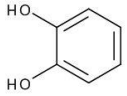
Multidentate ligands

These are ligands that can form more than one coordinate bond with the central metal ions due to their ability to donate more than one lone pair of electrons. Replacing monodentate ligands with multdentate ones is called chelation.

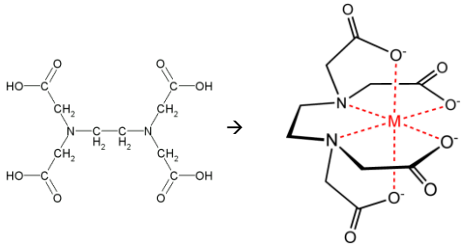
Examples are ethylenediamine or en ($NH_2CH_2CH_2NH_2$)



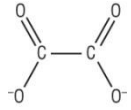
Benzene-1,2-diol



EDTA^{4-}



Ethanedioate ion



Complex ions with multidentate ligands are more stable than complex ions with monodentate ligands due to the increase in entropy:
$[Cu(H_2O)_6]^{2+} + EDTA^{4-} \rightarrow [Cu(EDTA)]^{2-} + 6H_2O$

A 2 CHEMISTRY

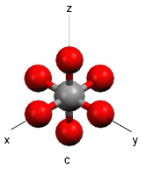
Transition metals

Question

State 3 different features of transition metal complexes that change the value of ΔE.

3 marks

Answer



Oxidation state of metal, type of ligand, size of ligand, type of central metal ion, shape of complex ion.

A 2 CHEMISTRY

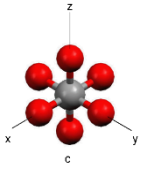
Transition metals

Question

Give the meaning of the term autocatalysed.

1 mark

Answer



The catalyst is a reaction product.

A 2 CHEMISTRY

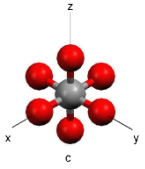
Transition metals

Question

Give the general property that allows transition metals to act as catalysts.

1 mark

Answer



They have variable oxidation states.

A 2 CHEMISTRY

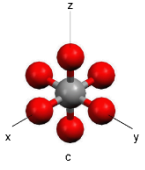
Transition metals

Question

Explain the meaning of the terms ligand and bidentate.

2 marks

Answer



A ligand is an electron pair donor. A bidentate ligand donates two pairs of electrons from two different atoms.

A 2 CHEMISTRY

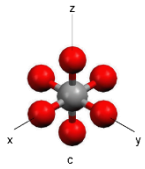
Transition metals

Question

Give one reason why impurities in the reactants can cause problems in processes that use heterogeneous catalysts.

1 mark

Answer



Impurities poison the catalyst.

A 2 CHEMISTRY

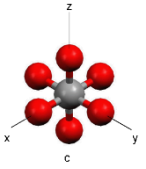
Transition metals

Question

Explain why complex ions have different colours.

3 marks

Answer



In different complexes, the d orbitals will have different energies. Light is absorbed causing an electron to be excited. Different frequencies of light be absorbed due to the differences in d-orbital energies.

A 2 CHEMISTRY

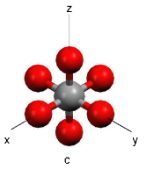
Transition metals

Question

List 4 transition metal shapes and give an example for each.

4 marks

Answer



Linear ($[Ag(NH_3)_2]^+$, square planar (cis-platin), tetrahedral ($[CuCl_4]^{2-}$), octrahedral (any aqua complex)

A 2 CHEMISTRY

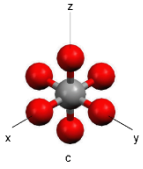
Transition metals

Question

In terms of bonding, define a complex.

1 mark

Answer



A central metal ion surrounded by ligands which form coordinate bonds with the metal ion.

A 2 CHEMISTRY

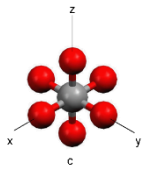
Transition metals

Question

Give the meaning of the term multidentate.

1 mark

Answer



A ligand that forms two or more dative covalent bonds with a central metal ion.

A 2 CHEMISTRY

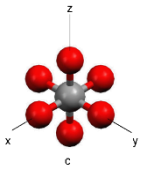
Transition metals

Question

Why can s-block elements not act as catalysts?

1 mark

Answer



Because they only exist in one oxidation state.

A 2 CHEMISTRY

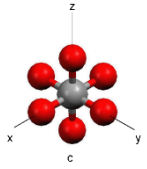
Transition metals

Question

Suggest what is done to heterogeneous catalysts to increase their efficiency.

2 marks

Answer



Spread the catalyst over a support base to increase the surface area of the catalyst.

A 2 CHEMISTRY

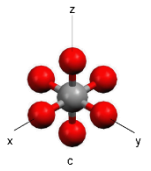
Transition metals

Question

What is a transition element?

3 marks

Answer



A metal that forms at least one ion with partially filled d-orbitals/ a partially filled d-subshell.

A 2 CHEMISTRY

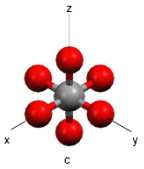
Transition metals

Question

State and explain one risk associated with using cis-platin as an anticancer drug.

2 marks

Answer



It binds to normal cells and kills them. This can lead to side effects such as hair loss.

A 2 CHEMISTRY

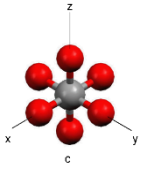
Transition metals

Question

What is the meaning of the symbols ΔE and h?

2 marks

Answer



Energy absorbed and Planck's constant.

A 2 CHEMISTRY

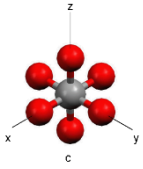
Transition metals

Question

What is the function of haemoglobin in the body?

1 mark

Answer



To transport oxygen/O_2.

A 2 CHEMISTRY

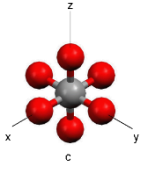
Transition metals

Question

With reference to haemoglobin, why is CO toxic?

2 marks

Answer



CO binds to haemoglobin and displaces the oxygen which can no longer be transported.

A 2 CHEMISTRY

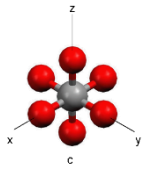
Transition metals

Question

How can poisoning of a catalyst be minimised?

1 mark

Answer



Remove impurities from the reactants.

A 2 CHEMISTRY

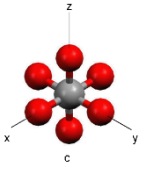
Transition metals

Question

In terms of electrons, explain why $CoSO_4$ is red in colour.

3 marks

Answer



Blue light is absorbed when an electron moves to a higher energy d-orbital. Red light is transmitted which is what we observe.

A 2 CHEMISTRY

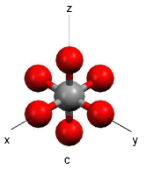
Transition metals

Question

State the formula and colour of the complex present in aqueous cobalt(II) sulfate.

2 marks

Answer



$[Co(H_2O)_6]^{2+}$
pink

A 2 CHEMISTRY

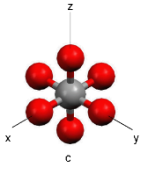
Transition metals

Question

What is the formula of the complex formed when a large excess of ammonia is added to aqueous cobalt(II) sulfate? Colour?

2 marks

Answer



$[Co(NH_3)_6]^{2+}$
Straw yellow.

A 2 CHEMISTRY

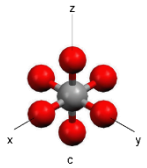
Transition metals

Question

Define coordination number.

1 mark

Answer



The number of coordinate bonds formed to a central metal ion.

A 2 CHEMISTRY

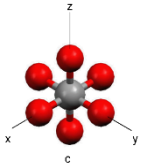
Transition metals

Question

What is formed when H_2O_2 is added to $[Co(NH_3)_6]^{2+}$?

2 marks

Answer



The hydrogen peroxide oxidises the Co form 2+ to 3+ forming red-brown $[Co(NH_3)_6]^{3+}$

A 2 CHEMISTRY

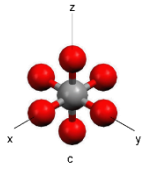
Transition metals

Question

What can you observe when aqueous ammonia reacts with aqueous Fe(II)?

2 marks

Answer



Pale green solution to green, gelatinous precipitate which is insoluble in excess ammonia.

A 2 CHEMISTRY

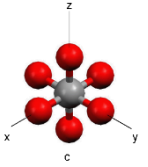
Transition metals

Question

What can you observe when aqueous ammonia reacts with aqueous Fe(III)?

2 marks

Answer



Yellow solution to brown, gelatinous precipitate which is insoluble in excess ammonia.

A 2 CHEMISTRY

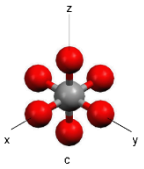
Transition metals

Question

Explain why transition metals which adsorb a) strongly or b) weakly are not usually good catalysts.

2 marks

Answer



a) The active site will be blocked/ products cannot desorb.

b) Reactant bonds will not weaken.

A 2 CHEMISTRY

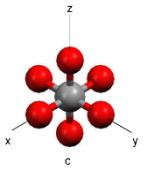
Transition metals

Question

Why are transition metal compounds coloured?

2 marks

Answer



Electrons absorb light in the visible region of the spectrum to transfer/excite to a high energy d-orbital.

A 2 CHEMISTRY

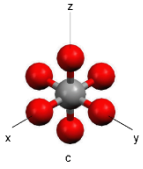
Transition metals

Question

What is meant by the term *chelate effect*?

2 marks

Answer



When monodentate ligands are substituted by bi- or multidentate ligands to give more stable complex ions due to an increase in entropy.

A 2 CHEMISTRY

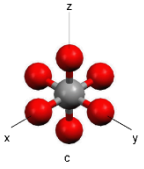
Transition metals

Question

What is a Lewis acid?

1 mark

Answer



An electron pair acceptor. (Lewis base is an electron pair donor)

A 2 CHEMISTRY

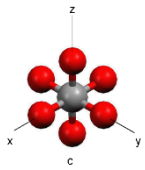
Transition metals

Question

Explain why the reaction between manganate ions and $C_2O_4^{2-}$ ions is slow to begin with.

1 mark

Answer



Both ions are negatively charged and repel. The activation energy is very high.

A 2 CHEMISTRY

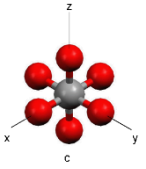
Transition metals

Question

What is a coordinate bond?

2 marks

Answer



A shared pair of electrons which has been donated by one atom to form a covalent bond.

A 2 TRANSITION METALS

CHEMISTRY

In aqueous solution, the $[Co(H_2O)_6]^{2+}$ ion reacts with an excess of ethane-1,2-diamine to form the complex ion **Y**.

Your response

A 2 TRANSITION METALS

CHEMISTRY

Write **two** equations to show how vanadium(V) oxide acts as a catalyst in the Contact Process.

Your response

A 2 TRANSITION METALS

CHEMISTRY

$[Co(H_2O)_6]^{2+} + 3H_2NCH_2CH_2NH_2 \rightarrow [Co(H_2NCH_2CH_2NH_2)_3]^{2+} + 6H_2O$

Mark scheme

Entropy is increased as the number of particles increases from 4 to 7 which means the en complex is more stable than the aqua complex.

Comment

A 2 TRANSITION METALS

CHEMISTRY

$V_2O_5 + SO_2 \rightarrow V_2O_4 + SO_3$

$V_2O_4 + ½O_2 \rightarrow V_2O_5$

Mark scheme

Equations can be multiples.

Comment

A 2 TRANSITION METALS

CHEMISTRY

Write **two** equations to show how the autocatalyst is involved in this oxidation of $C_2O_4^{2-}$ ions by MnO_4^- ions.

Your response

A 2 TRANSITION METALS

CHEMISTRY

Describe what you would observe when dilute aqueous NaOHis added, dropwise until in excess, to a dilute aqueous solution containing chromium(III) ions. Write **two** equations to illustrate your observations.

Your response

A 2 TRANSITION METALS

CHEMISTRY

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

$2Mn^{3+} + C_2O_4^{2-} \rightarrow 2Mn^{2+} + 2CO_2$

Mark scheme

Comment

A 2 TRANSITION METALS

CHEMISTRY

Green precipitate

(Dissolves to form a) green solution
Solution can be implied if 'dissolves' stated

$[Cr(H_2O)_6]^{3+} + 3OH^- \rightarrow Cr(H_2O)_3(OH)_3 + 3H_2O$

$Cr(H_2O)_3(OH)_3 + 3OH^- \rightarrow [Cr(OH)_6]^{3-} + 3H_2O$

Penalise $Cr(OH)_3$ once only.

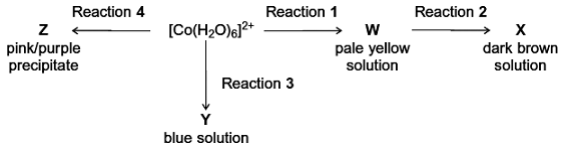
Mark scheme

Comment

A 2 TRANSITION METALS

CHEMISTRY

For each of the reactions 1 to 4, identify a suitable reagent. Identify W, X, Y and Z.



Your response

A 2 TRANSITION METALS

CHEMISTRY

Write an equation for the reaction, in aqueous solution, between $[Cu(H_2O)_6]^{2+}$ and an excess of chloride ions.
State the shape of the complex produced and explain why the shape differs from that of the $[Cu(H_2O)_6]^{2+}$ ion.

Your response

A 2 TRANSITION METALS

CHEMISTRY

1 ammonia solution
W is $[Co(NH_3)_6]^{2+}$
2 H_2O_2
X is $[Co(NH_3)_6]^{3+}$
3 HCl
Y is $[CoCl_4]^{2-}$
4 Na_2CO_3
Z is $CoCO_3$

Mark scheme

Comment

A 2 TRANSITION METALS

CHEMISTRY

$[Cu(H_2O)_6]^{2+} + 4Cl^- \rightarrow [CuCl_4]^{2-} + 6H_2O$

tetrahedral

Cl^- / Cl / chlorine too big
(to fit more than 4 round Cu)

Penalise HCl. Allow water smaller than Cl-

Mark scheme

Comment

A 2 TRANSITION METALS

CHEMISTRY

Draw the structure of the ethanedioate ion ($C_2O_4^{2-}$). Explain how this ion is able to act as a ligand.

Your response

A 2 TRANSITION METALS

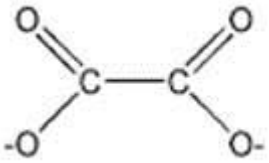
CHEMISTRY

Draw a diagram to show how ethanedioate ions ($C_2O_4^{2-}$) are bonded to a copper ion. Two water molecules are opposite each other which you do not need to draw.

Your response

A 2 TRANSITION METALS

CHEMISTRY



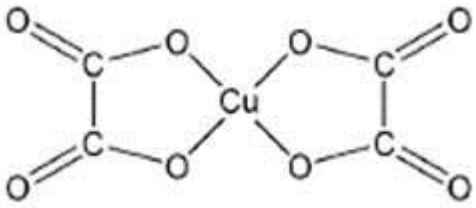
lone pair(s) on O^- / O are used to form 2 coordinate bonds.

Mark scheme

Comment

A 2 TRANSITION METALS

CHEMISTRY



The O-Cu-O bond angle is 90°.

Mark scheme

Comment

A 2 TRANSITION METALS

CHEMISTRY

Explain how and why iron ions catalyse the reaction between iodide ions and $S_2O_8^{2-}$ ions. Write equations for the reactions that occur.

Your response

A 2 TRANSITION METALS

CHEMISTRY

Explain, with the aid of an equation, why iron(III) ions are more acidic than iron(II) ions in aqueous solution.

Your response

A 2 TRANSITION METALS

CHEMISTRY

Mark scheme

$2Fe^{2+} + S_2O_8^{2-} \rightarrow 2Fe^{3+} + 2SO_4^{2-}$

$2Fe^{3+} + 2I^- \rightarrow 2Fe^{2+} + I_2$

Comment

The iron ions can change oxidation states which makes them suitable catalysts.

A 2 TRANSITION METALS

CHEMISTRY

Mark scheme

$[Fe(H_2O)_6]^{3+} \rightarrow [Fe(H_2O)_5OH]^{2+} + H^+$

Fe^{3+} ion has higher charge (to size ratio) (than Fe^{2+})

increases polarisation of co-ordinated water / attracts O

releasing an H^+ ion / weakens O–H bond

Comment

All 3+ ions are more polarising than their 2+ ions.

A 2 TRANSITION METALS

CHEMISTRY

Some sodium carbonate solution was added to a solution containing iron(III) ions. Describe what you would observe and write an equation for the reaction that occurs.

Your response

A 2 TRANSITION METALS

CHEMISTRY

In a titration, 0.321 g of a moss killer reacted with 23.60 cm^3 of acidified 0.0218 mol dm^{-3} $K_2Cr_2O_7$ solution. Calculate the percentage by mass of iron in the moss killer. Assume that all of the iron in the moss killer is in the form of iron(II).

Your response

A 2 TRANSITION METALS

CHEMISTRY

Mark scheme

brown precipitate / solid
Allow red-brown / orange solid
Not red or yellow solid
bubbles (of gas) / effervescence/ fizz

$2[Fe(H_2O)_6]^{3+} + 3CO_3^{2-} \rightarrow 2Fe(H_2O)_3(OH)_3 + 3CO_2 + 3H_2O$

Comment

Just CO_2 is not allowed as an observation.

A 2 TRANSITION METALS

CHEMISTRY

Mark scheme

$Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+} \rightarrow 2Cr^{3+} + 7H_2O + 6Fe^{3+}$
moles dichromate = $23.6 \times 0.218/1000 = 5.14 \times 10^{-4}$
moles iron = $5.14 \times 10^{-4} \times 6 = 0.00309$
mass iron = $0.00309 \times 55.8 = 0.172$
% by mass of iron = $0.172 \times 100/0.321 = 53.7\%$

Comment

A 2 TRANSITION METALS

CHEMISTRY

$[Cr(H_2O)_6]^{3+}$ —(Reaction 3; Excess NaOH(aq))→ chromium(III) complex

For Reaction 3, state the colour of the initial and of the final solution and write an equation for the reaction.

Your response

A 2 TRANSITION METALS

CHEMISTRY

Write a half-equation for the reduction of hydrogen peroxide to hydroxide ions. Deduce an overall equation for Reaction 4 and state the colour of the final solution.

chromium(III) complex —(Reaction 4; H_2O_2)→ CrO_4^{2-}

Your response

A 2 TRANSITION METALS

CHEMISTRY

Ruby/red-blue/purple/violet/green

Green

$[Cr(H_2O)_6]^{3+} + 6OH^- \rightarrow [Cr(OH)_6]^{3-} + 6H_2O$

Mention of a precipitate negates marks 2 & 3.

Mark scheme

Comment

A 2 TRANSITION METALS

CHEMISTRY

$H_2O_2 + 2e^- \rightarrow 2OH^-$

$2[Cr(OH)_6]^{3-} + 3H_2O_2 \rightarrow 2CrO_4^{2-} + 8H_2O + 2OH^-$

Yellow

Mark scheme

Comment

A 2 TRANSITION METALS

CHEMISTRY

Write two equations to show how Fe^{2+} ions can catalyse the reaction between $S_2O_8^{2-}$ ions and I^- ions. Suggest one reason why the activation energy for each of these reactions is low.

Your response

A 2 TRANSITION METALS

CHEMISTRY

State the electron configurations of a Ti(III) ion and Ti(IV) ion. Explain, in terms of electron configurations and electron transitions, why Ti(III) compounds are usually coloured but Ti(IV) compounds are colourless.

Your response

A 2 TRANSITION METALS

CHEMISTRY

$2Fe^{2+} + S_2O_8^{2-} \rightarrow 2Fe^{3+} + 2SO_4^{2-}$

$2Fe^{3+} + 2I^- \rightarrow 2Fe^{2+} + I_2$

Positive and negative (ions)/ oppositely charged (ions) attract

Mark scheme

This is the opposite to the MnO_4^- /$C_2O_4^{2-}$ reaction which has a high activation energy as both ions are negatively charged.

Comment

A 2 TRANSITION METALS

CHEMISTRY

Ti(IV) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

Ti(III) $[Ar]3d^1$

Ti(III) has a d electron that can be excited to a higher level

Absorbs one colour of light from white light

Ti(IV) has no d electron so no electron transition with energy equal to that of visible light

Mark scheme

Comment

A 2 TRANSITION METALS
CHEMISTRY

For each of the following, identify a complex ion responsible for the colour of the aqueous solution.
A) A deep blue solution formed in an excess of concentrated aqueous ammonia.
B) A green solution formed in an excess of aqueous sodium hydroxide.
C) A yellow–green solution formed in an excess of concentrated hydrochloric acid.

Your response

A 2 TRANSITION METALS
CHEMISTRY

Give two reasons why the use of a spectrometer is the most appropriate method for measuring the concentration of coloured ions during the autocatalysed reaction between permanganate and $C_2O_4^{2-}$ ions.

Your response

A 2 TRANSITION METALS
CHEMISTRY

$[Cu(NH_3)_4(H_2O)_2]^{2+}$

$[Cr(OH)_6]^{3-}$

$[CuCl_4]^{2-}$

Mark scheme

Comment

A 2 TRANSITION METALS
CHEMISTRY

Rapid determination of concentration
Or easy to get many readings

Does not use up any of the reagent/does not interfere
with the reaction

Mark scheme

Comment

A 2 TRANSITION METALS

CHEMISTRY

For the reaction between MnO_4^- and $C_2O_4^{2-}$ sketch a curve to show how you would expect the concentration of manganate(VII) ions to change with time until the colour has faded because the concentration has reached a very low value. Explain the shape of the curve.

Your response

A 2 TRANSITION METALS

CHEMISTRY

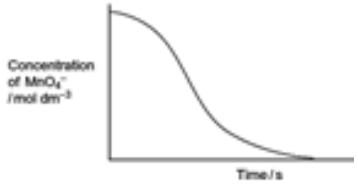
In aqueous solution, Fe^{2+} ions act as a homogeneous catalyst in the reaction between I^- and $S_2O_8^{2-}$ ions. Give one reason why the reaction is slow in the absence of a catalyst.

Your response

A 2 TRANSITION METALS

CHEMISTRY

Curve starts with small gradient (low rate)
Because negative ions collide so E_a high
Curve gets steeper
Because autocatalyst (Mn^{2+}) formed
Curve levels out approaching time axis
Because MnO_4^- ions used up



Mark scheme

Comment

A 2 TRANSITION METALS

CHEMISTRY

Both ions are negatively charged and repel. The activation energy is high as a result.

This is the same argument for the MnO_4^- and $C_2O_4^{2-}$ autocatalysis reaction.

Mark scheme

Comment

A 2 TRANSITION METALS

CHEMISTRY

Write half-equations for the oxidation of Fe^{2+} and for the reduction of $Cr_2O_7^{2-}$ in acidic solution, and use these to construct an overall equation for the reaction between these two ions.

Your response

A 2 TRANSITION METALS

CHEMISTRY

State what is observed when an excess of aqueous ammonia reacts with an aqueous iron(II) salt. Write an equation for this reaction.

Your response

A 2 TRANSITION METALS

CHEMISTRY

$Fe^{2+} \rightarrow Fe^{3+} + e^-$

$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

$Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+} \rightarrow 2Cr^{3+} + 7H_2O + 6Fe^{3+}$

You need to be able to recite this equation in your sleep!

Mark scheme

Comment

A 2 TRANSITION METALS

CHEMISTRY

Pale green solution at the start

Green precipitate formed which is

Insoluble in excess ammonia

Equation:
$[Fe(H_2O)_6]^{2+} + 2NH_3 \rightarrow$
$[Fe(OH)_2(H_2O)_4] + 2NH_4^+$

Mark scheme

Comment

A 2 TRANSITION METALS

CHEMISTRY

When aqueous ammonia was added to an aqueous solution of cobalt(II) sulphate, a blue precipitate M was formed. Identify the cobalt-containing species present in aqueous cobalt(II) sulphate and the precipitate M.

Your response

A 2 TRANSITION METALS

CHEMISTRY

Using half-equations, construct an overall equation for the reduction of to V^{2+} by zinc in acidic solution.

Your response

A 2 TRANSITION METALS

CHEMISTRY

Cobalt-containing species: $[Co(H_2O)_6]^{2+}$

Precipitate M: $Co(H_2O)_4(OH)_2$

Mark scheme

Comment

A 2 TRANSITION METALS

CHEMISTRY

$VO_2^+ + 4H^+ + 3e^- \rightarrow V^{2+}(aq) + 2H_2O$

$Zn \rightarrow Zn^{2+} + 2e^-$

$2VO_2^+ + 8H^+ + 3Zn \rightarrow 3Zn^{2+} + 2V^{2+}(aq) + 4H_2O$

Remember to use H^+ and H_2O or OH^- to balance redox half equations.

Mark scheme

Comment

A 2 TRANSITION METALS
CHEMISTRY

Give the formula of a linear complex ion, a tetrahedral complex ion and an octahedral complex ion formed by using a bidentate ligand.

Your response

A 2 TRANSITION METALS
CHEMISTRY

Identify a reagent, or mixture of reagents, necessary to carry out each of the following conversion
$[Cr(H_2O)_6]^{3+}(aq) \rightarrow CrO_4^{2-}(aq)$

Your response

A 2 TRANSITION METALS
CHEMISTRY

Linear: $[Ag(NH_3)_2]^+$
Tetrahedral :$[CoCl_4]^{2-}$
Octahedral :$[Fe(H_2NCH_2CH_2NH_2)_3]^{3+}$

Mark scheme

For the tetrahedral complex, Cu would be suitable.
For the octahedral complex, the central metal ion could differ.

Comment

A 2 TRANSITION METALS
CHEMISTRY

$\underline{H_2O_2}$ plus NaOH

Mark scheme

Comment

A 2 CHEMISTRY

TRANSITION METALS

When a solution containing $[Co(H_2O)_6]^{2+}$ ions is treated with a solution containing $EDTA^{4-}$ ions, a more stable complex is formed. Write an equation for this reaction.

Your response

A 2 CHEMISTRY

TRANSITION METALS

The reaction between aqueous persulphate ions and iodide ions, $I^-(aq)$, is catalysed by $Fe^{2+}(aq)$ ions. Suggest why this reaction has a high activation energy.
Suggest why $V^{3+}(aq)$ ions will also act as a catalyst for this reaction but $Mg^{2+}(aq)$ ions will not.

Your response

A 2 CHEMISTRY

TRANSITION METALS

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

Mark scheme

Remember that there are now 7 molecules on the RHS, which means entropy has increased, as has stability.

Comment

A 2 CHEMISTRY

TRANSITION METALS

Vanadium is a transition element **or**
Magnesium is not a transition element
Vanadium has variable oxidation states
Magnesium only forms Mg^{2+}, or has only one oxidation state

Mark scheme

These types of questions simply test that you know the properties of transition metals.

Comment

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PAST PAPER QUESTIONS

Updated 1 February 2015

AQA PAST PAPERS & MARKSCHEMES- SELECT UNIT 5

A LEVEL CHEMISTRY WEBPAGE

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TRANSITION METALS

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RSC STARTER FOR 10 (further exercises)-
13. Transition metal chemistry

CHEMGUIDE

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