# 13.1 Transition Metals

## Question Paper

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| Course | DP IB Chemistry |
| Section | 13. The Periodic Table- Transition Metals (HL only) |
| Topic | 13.1 Transition Metals |
| Difficulty | Hard |

**Time allowed:** 40

**Score:** /31

**Percentage:** /100

## Question 1a

a)
When chromium(III) sulfate dissolves in water, a green solution containing the $[Cr(H_2O)_6]^{3+}$ ion forms.

i)
State the bond angles found in this complex ion.

[1]

ii)
Explain why the chromium(III) complex ion is coloured.

[3]

**[4 marks]**

## Question 1b

b)
Vanadium(V) oxide is the catalyst used in the Contact process as shown by the reactions:

$$SO_2(g) + V_2O_5(s) \rightarrow SO_3(g) + V_2O_4(s)$$

$$V_2O_4(s) + ½O_2(g) \rightarrow V_2O_5(s)$$

i) Explain, using the equations, why $V_2O_5$ is a catalyst.

[1]

ii) Explain why $V_2O_5$ can act as a catalyst in this reaction.

[1]

**[2 marks]**

## Question 1c

c)
Excess ammonia is added to a solution of $Cu^{2+}$ ions resulting in the substitution of 4 ligands.
Using section 15 of the data booklet, explain why this reaction results in a shift in the wavelength of light absorbed by the $Cu^{2+}$ complex.

[1]

**[1 mark]**

## Question 2a

a)
Iron is a transition element that forms several ions with iron in different oxidation states.

Deduce the condensed electron configuration of the iron cation that can form the complex ion $[Fe(CN)_6]^{4-}$.

[1]

**[1 mark]**

## Question 2b

b)
Co(III) has the same electron configuration as the iron cation in part(a).
Explain why, despite this, solutions of the two ions are different colours.

[2]

**[2 marks]**

## Question 2c

c)
Rhenium forms salts containing the perrhenate(VII) ion, $ReO_4^-$.

Suggest why the existence of salts containing an ion with this formula could be predicted. Refer to section 6 of the data booklet.

[1]

**[1 mark]**

## Question 2d

d)

Rhenium is used with platinum to speed up reactions used in the production of gasoline.

Predict **two** other chemical properties you would expect rhenium to have, given its position in the periodic table.

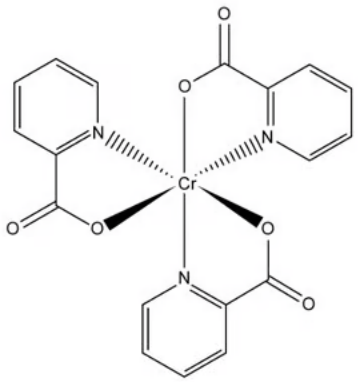
[2]

**[2 marks]**

## Question 3a

a)

Chromium (III) picolinate, shown below, is often used in tablets as a nutritional supplement for chromium.




i) Draw the structure of the ligand in chromium(III) picolinate.

[1]

ii) State the coordination number of chromium in chromium(III) picolinate.

[1]

**[2 marks]**

## Question 3b

b)
A complex of cobalt has the following composition by mass:

Co, 21.98%; N, 31.35%; H, 6.81%; Cl, 39.86%

i)
Calculate the empirical formula of this complex.

ii)
The formula of this cobalt complex can be expressed in the form $[Co(L)_m]^{x+}(Cl^-)_n$.
Suggest the chemical formula of $[Co(L)_m]^{x+}$.

[3]

**[3 marks]**

## Question 3c

c)
$Ni(ClO_4)_2$ reacts with water to form the complex ion $[Ni(H_2O)_6][ClO_4]_2$.
Explain this reaction in terms of an acid-base theory.

[2]

**[2 marks]**

## Question 3d

d)
Nickel(II) forms a complex ion with water, $[Ni(H_2O)_6]^{2+}$

i)
Outline how the bond is formed between $Ni^{2+}$ and $H_2O$ during the formation of the complex.

[1]

ii} State the geometry of the complex formed.

[1]

**[2 marks]**

## Question 4a

a)

1,2-diaminoethane is a bidentate ligand which can form a complex with $[Co(NH_3)_4(H_2O)_2]^{2+}$. In this reaction, only the ammonia molecules are replaced.

i) Write an equation for this reaction.

[1]

ii) State the molecular geometry of the complex formed.

[1]

**[2 marks]**

## Question 4b

b)

Consider the complex $[Ni(NH_3)_6]Cl_2$

i)

Deduce the condensed electron configuration of the Ni.

[1]

ii)

Explain whether the complex is paramagnetic or diamagnetic.

[2]

**[3 marks]**

## Question 4c

c)
Explain why Ti forms variable oxidation states, but Ca only occurs in the +2 oxidation state.

[2]

**[2 marks]**

## Question 4d

d)
Explain the magnetic nature of the complex $[Cr(H_2O)_6]Cl_3$.

**[2 marks]**