IB Chemistry – HL

Topic 3 Questions

1. Which of the following salts form coloured solutions when dissolved in water?

I. $ScCL_3$

II. $FeCl_3$

III. $NiCl_2$

IV. $ZnCl_2$

A. I and II only

B. II and III only

C. III and IV only

D. I, II, III and IV

(Total 1 mark)

2. Which is an essential feature of a ligand?

A. a negative charge

B. an odd number of electrons

C. the presence of two or more atoms

D. the presence of a non-bonding pair of electrons

(Total 1 mark)

3. Which equation represents the third ionization energy of an element M?

A. $M^{+}(g) \rightarrow M^{4+}(g) + 3e^{-}$

B. $M^{2+}(g) \rightarrow M^{3+}(g) + e^{-}$

C. $M(g) \rightarrow M^{3+}(g) + 3e^{-}$

D. $M^{3+}(g) \rightarrow M^{4+}(g) + e^{-}$

(Total 1 mark)

4. Which electrons are lost by an atom of iron when it forms the Fe^{3+} ion?

A. One s orbital electron and two d orbital electrons

B. Two s orbital electrons and one d orbital electron

C. Three s orbital electrons

D. Three d orbital electrons

(Total 1 mark)

5. Which properties are typical of d-block elements?

I. complex ion formation

II. catalytic behaviour

III. colourless compounds

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

(Total 1 mark)

6. Which combination of ion charge and ion size produces the greatest lattice enthalpy?

A. High charge, large size

B. High charge, small size

C. Low charge, small size

D. Low charge, large size

(Total 1 mark)

7. Which salts form coloured solutions when dissolved in water?

I. $FeCl_3$
II. $NiCl_2$
III. $ZnCl_2$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

(Total 1 mark)

8. Which combination is correct for the complex ion in $[Co(NH_3)_4(H_2O)Cl]Br$?

Oxidation state of cobalt	Shape of the complex ion	Overall charge of the complex ion

A.	+2	Octahedral	+2
B.	+3	Octahedral	–1
C.	+2	Octahedral	+1
D.	+2	Tetrahedral	+1

(Total 1 mark)

9. Define the term *ligand*. $Cu^{2+}(aq)$ reacts with ammonia to form the complex ion $[Cu(NH_3)_4]^{2+}$. Explain this reaction in terms of an acid-base theory, and outline the bonding in the complex ion formed between Cu^{2+} and NH_3.

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(Total 4 marks)

10. By reference to the structure and bonding in the compounds NaCl and $SiCl_4$

(i) state and explain the differences in conductivity in the liquid state.

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(3)

(ii) predict an approximate pH value for a solution formed by adding each compound separately to water.

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(4)
(Total 7 marks)

11. Two characteristics of the d-block (transition) elements are that they exhibit variable oxidation states and form coloured compounds.

(i) State **two** possible oxidation states for iron and explain these in terms of electron arrangements.

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(2)

(ii) Explain why many compounds of d-block (transition) elements are coloured.

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(3)
(Total 5 marks)

12. Silicon tetrachloride, $SiCl_4$, reacts with water to form an acidic solution.

(i) Explain why silicon tetrachloride has a low melting point.

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(2)

(ii) Write an equation for the reaction of silicon tetrachloride with water.

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(1)
(Total 3 marks)

13. Magnesium chloride and silicon(IV) chloride have very different properties.

(i) Give the formula and physical state at room temperature of each chloride.

(2)

(ii) State the conditions under which, if at all, each chloride conducts electricity.

(2)

(iii) Each chloride is added to water in separate experiments. Suggest an approximate pH value for the solution formed, and write an equation for any reaction that occurs.

(3)
(Total 7 marks)

14. The elements in the d-block in the periodic table have several characteristics in common.

(i) Give the electronic configuration of Ni^{2+}.

(1)

(ii) Explain what is meant by a ligand, and describe the type of bond formed between a ligand and a d-block element.

(2)

(iii) Determine the oxidation numbers of copper in the species

$$[Cu(NH_3)_4]^{2+} \text{ and } [CuCl_4]^{2-}$$

(2)

(iv) Explain why the species in (iii) are coloured.

(3)

(v) Identify the d-block element used as a catalyst in the Haber process and write an equation for the reaction occurring.

(2)
(Total 10 marks)

15. (i) Explain why complexes of Zn^{2+} are colourless whereas complexes containing Cu^{2+} are coloured.

(3)

(ii) Give the formula and describe the shape of the complex ion formed between Fe^{3+} and the

ligand CN^-.

(2)
(Total 5 marks)

16. Consider the transition metal complex, $K_3[Fe(CN)_6]$.

(i) Define the term *ligand*, and identify the ligand in this complex.

(1)

(ii) Write the full electron configuration and draw the orbital box diagram of iron in its oxidation state in this complex, and hence, determine the number of unpaired electrons in this state.

(3)

(iii) Explain why many transition metal d-block complexes are coloured.

(3)
(Total 7 marks)

17. By reference to the structure and bonding in NaCl and $SiCl_4$:

(i) State and explain the differences in electrical conductivity in the liquid state.

(3)

(ii) Predict an approximate pH value for the solutions formed by adding each compound separately to water. Explain your answer.

(4)
(Total 7 marks)

18. Elements with atomic number 21 to 30 are d-block elements.

(a) Identify which of these elements are **not** considered to be typical transition elements.

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(1)

(b) Complex ions consist of a central metal ion surrounded by ligands. Define the term *ligand*.

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(2)

(c) Complete the table below to show the oxidation state of the **transition element**.

(3)

ion	$Cr_2O_7^{2-}$	$[CuCl_4]^{2-}$	$[Fe(H_2O)_6]^{3+}$
oxidation state			

(d) Identify **two** transition elements used as catalysts in industrial processes, stating the

process in each case.

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(2)

(e) Apart from the formation of complex ions and apart from their use as catalysts, state **two** other properties of transition elements.

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(2)

(Total 10 marks)