JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES

UNIVERSITY EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION (SCIENCES)

3rd YEAR 1ST SEMESTER 2018/2019 ACADEMIC YEAR

MAIN REGULAR

COURSE CODE: SCH 306

COURSE TITLE: INORGANIC CHEMISTRY II

EXAM VENUE: **STREAM: (BEd. Science)**

DATE:

TIME: **EXAM SESSION:**

INSTRUCTIONS:

1. **Answer question 1 (Compulsory) in section A and ANY other 2 questions in Section B.**
2. **Candidates are advised not to write on the question paper.**
3. **Candidates must hand in their answer booklets to the invigilator while in the examination room.**
4. **Some important information/formulas are found on the last page of this question paper**

SECTION A

Question 1

a) Briefly describe the differences between (3 marks)

i. Monodentate and bidentate ligands

ii. Anionic and neutral ligands

iii. Neutral complexes, complex cations and complex anions

b) Transition elements (3-*d* elements) have various industrial uses. Give at least one function for five of the transition metal elements (5 marks)

c) Draw the energy level diagram for the ion iron (Zn^{2+}) (2 marks)

d) Give the electronic configuration for Sc, Cr, Mn, and Zn. Use this information to explain why compounds of Sc and Zn are not colored (4 marks)

e) Use the electron box and arrow configurations in combination with Pauli exclusion principle and Hund's rule to demonstrate the electronic configuration of V^{+}, V^{2+}, V^{3+}, V^{4+}, and V^{5+}. (3 marks)

f) Draw the geometrical structures of $[Cu(Cl)_4]^{2-}$ and $[Cu(NH_3)_4]^{2+}$ Complex ions. (2 marks)

g) Determine the oxidation number and coordination number of $[Ag(NH_3)_2]^{+}$ and $[NiCl_2(NH_3)_2]$ complex ions (4 marks)

h) By use of a diagram, demonstrate the changes in the boiling and melting points of the 3d elements. (3 marks)

i) Briefly discuss the Molecular Orbital Diagram for the Oxygen molecule and determine it is bond order. (4 marks)

Section B. Answer any <u>TWO</u> questions

Question 2

a) Transition metals form colored compounds and complexes. These colors can vary depending on the charge on the metal ion and the number and type of groups of atoms (ligands) attached to the metal ion. In aqueous solutions, the ions form complexes with different colors. Give an explanation for the coloration. (2 marks)

b) Give the IUPAC names of the following complex anions (6 marks)

i. $[TiCl_5]^-$

ii. $[VCl_6]^{2-}$

iii. $[MnBr(CO)_5]$

iv. $[Fe(OH)(H_2O)_5]SO_4$

v. $[V(NH_3)_6]^{3+}$

vi. $[CoCl(CN)(NO_2)(NH_3)_3$

c) Using diagrams, illustrate the valence bond models for the following complex ions.

i. Octahedral Complex e.g. $[Cr(NH_3)_6]^{3+}$ (4 marks)

ii. Tetrahedral *e.g.* $[Zn(OH)_4]^{2-}$ (4 marks)

iii. Square Planar *e.g.* $[Ni(CN)_4]^{2-}$ (4 marks)

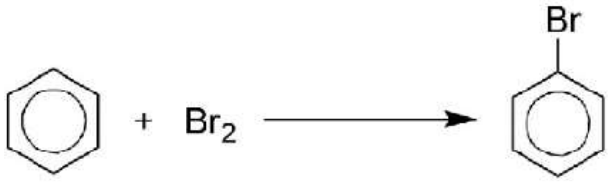
Question 3

a) Briefly describe the formation of a covalent bond using molecular orbital theory. (3 marks)

b) Extraction of copper from sulphide ores consists of four main stages under the pyrometallurgical method namely, mining, milling, smelting, and refining. Briefly describe the smelting and refining stages. (6 marks)

c) The commonest ore of copper is chalcopyrite ($CuFeS_2$). Copper can be extracted by two principal methods, pyrometallurgical method and hydrometallurgical method. Give a brief description of these two methods. (6 marks)

j) Given the following reactions, provide a d block element that can be used to catalyze them. (3 marks)

i. 

ii. $2\ SO_2(g) + O_2(g) \longrightarrow 2\ SO_3(g)$

iii. 

k) Divalent (M^{2+}) and trivalent (M^{3+}) transition metal centres form octahedral hexaaqua-complexes of the type $[M(H2O)6]^{n+}$, Give the structural formula of this complex. (2 marks)

Question 4

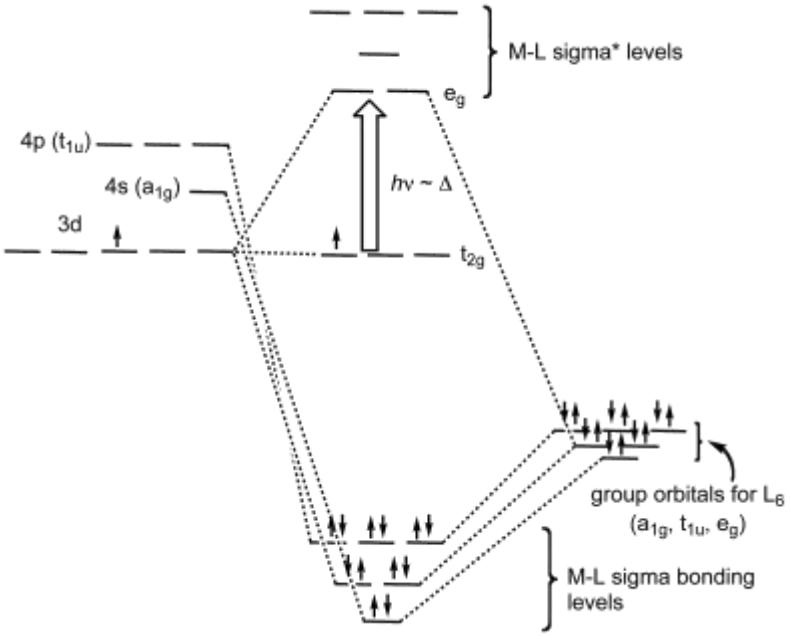
a) Briefly describe the Crystal Field Splitting Energy (CFSE) for the complex ion $[Fe(CN)_6]^{3-}$. (5 marks)

b) Given that the CFSE of $[Co(H_2O)_6]^{2+}$ is -0.8 Δ_{oct}, illustrate its spin state. (5 marks)

c) Iron is one of the most important metals. It occurs in nature as oxides or sulphides for example haematite Fe_2O_3; magnetite Fe_3O_4; iron pyrites FeS_2. Iron is obtained by the reduction of its oxides with carbon monoxide. The iron ore contains haematite, *i.e.* Fe_2O_3.

Reduction of Fe_2O_3 to Fe by carbon monoxide takes place in a blast furnace at temperatures as high as 800-2000 ^oC as shown below. Give the balanced chemical equation of all the reactions in this process starting from generation of CaO. (6 marks)

l) Ligand field theory (LFT) describes the bonding, orbital arrangement, and other characteristics of coordination complexes. It represents an application of molecular orbital theory to transition metal complexes. A transition metal ion has nine valence atomic orbitals - consisting of five *n*d, one *(n+1)*s, and three *(n+1)*p orbitals. These orbitals are of appropriate energy to form bonding interaction with ligands (see the figure below).

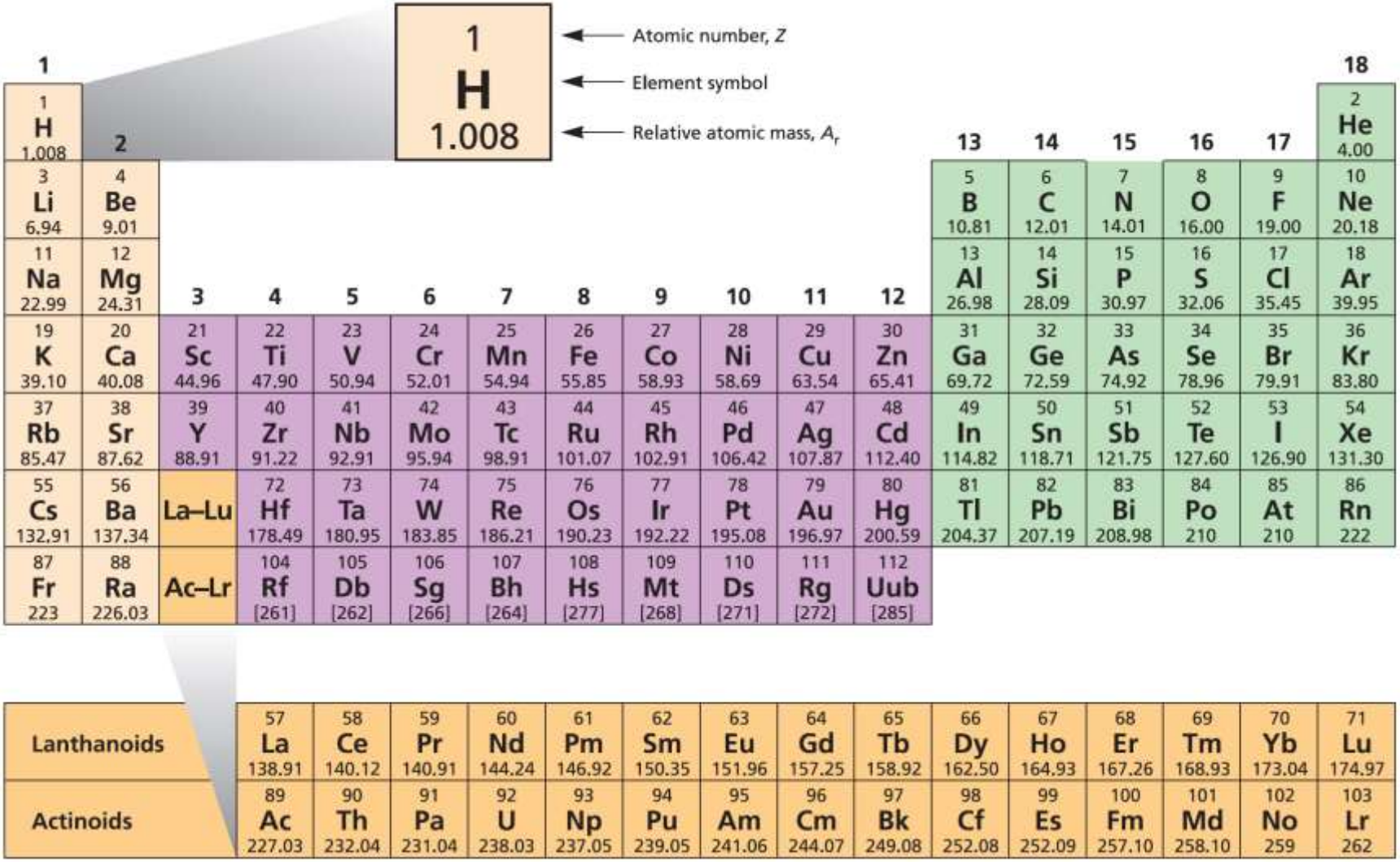


Using this information, give a brief description of the following bonding theories.

i. σ-Bonding (sigma bonding). (2 marks)

ii. π-bonding (pi bonding). (2 marks)

Periodic table



Geometry

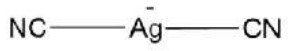
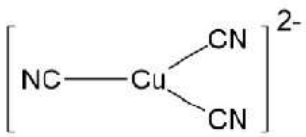
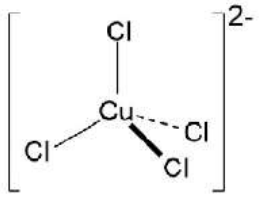
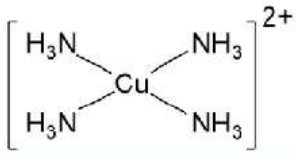
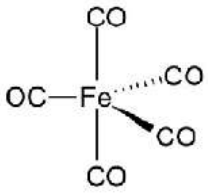
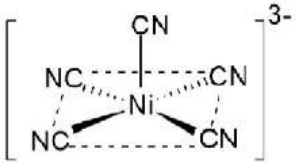
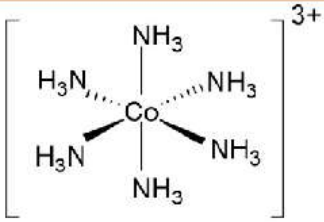
C.N.	Geometry (formula)		Example
2	Linear	$[ML_2]$	
3	Trigonal planar	$[ML_3]$	
4	Tetrahedral	$[ML_4]$	
4	Square planar	$[ML_4]$	
5	Trigonal bipyramidal	$[ML_5]$	
5	Square pyramidal	$[ML_5]$	
6	Octahedral	$[ML_6]$	

Table1: Variation of geometry with the coordination number of the metal