



FACULTY OF ENGINEERING AND ENVIRONMENT
DEPARTMENT OF METALLURGICAL/MINING ENGINEERING

INTRODUCTION TO CHEMISTRY

EMR/EMI 1104

Final Examination Paper

January 2019

This examination paper consists of 4 pages

Time Allowed: 3 hours

Total Marks: 100

Examiner's Name: Dr P. Ncube

INSTRUCTIONS

1. Answer **ALL** questions in Section A and **ANY THREE (3)** questions in Section B
2. Section A carries 40 marks and each question in Section B carries 20 marks
3. Use of calculators is permissible

Additional Requirements

MARK ALLOCATION

Question 1	40 Marks
Questions 2 - 5	20 Marks each
Total Attainable Marks	100

SECTION A

1) (a) Write the electron configurations of the following species.

(i) Cs (ii) Se (iii) Cr (iv) Cr^{3+} **[4 marks]**

(b) Explain what is wrong with the following electron configurations for atoms in their ground state?

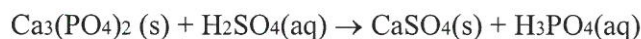
(i) $1s^2 2s^2 2p^6 3s^3$ (ii) $[\text{Ne}] 2s^2 2p^3$ (iii) $[\text{Ne}] 3s^2 3d^5$ **[3 marks]**

(c) Determine the molecular geometry of the following:

(i) BF_3 (ii) NO_2 (iii) CH_4 (iv) NH_3 (v) H_2O

In each case indicate clearly the number of bonding and non-bonding electron domains as

well as the approximate bond angles, around the central atom. **[10 marks]** (c) Consider the following unbalanced equation:

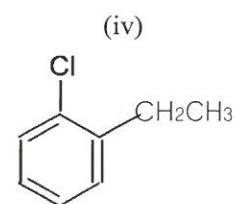
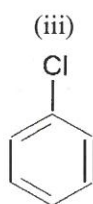
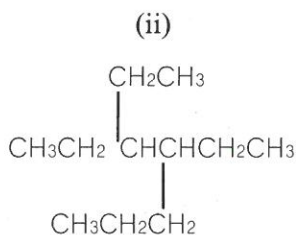
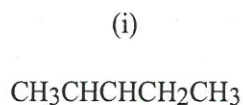


(i) Balance the equation. **[1 marks]** (ii) Calculate the molecular mass of each compound in the equation. **[6 marks]**

(iii) What mass of CaSO_4 is produced from 50 g of $\text{Ca}_3(\text{PO}_4)_2$ and excess H_2SO_4 ?

[8 marks]

(d) Give the IUPAC names of the following compounds.



[4 marks]

(e) The following names are incorrect. Draw the structures and provide correct names.

(i) 3-propyl-4,7-dimethyl nonane (ii) 2-methyl-hept-5-ene

[4 marks]

SECTION B

2) (a) State the VSEPR theory and show how this system applies to molecules containing 2, 3 and 4 electron domains. [4 marks]

(b) For each of the following molecular species draw the Lewis dot structure

(i) NH_4^+ (ii) ICl_4^- (iii) NH_2^- (iv) XeOF_4 [8 marks]

(ii) Use the VSEPR theory to predict the shape of each of species. [4 marks]

(c) Explain why the bond angle of the CH_4 molecule is much higher than that of the NH_3 and H_2O molecules even though they all have the same electron domain geometry. Use Lewis structures to explain your answer. [4 marks]

3) (a) There are two binary compounds of mercury and oxygen. On heating either of the compounds, decomposition occurs, with oxygen gas escaping into the atmosphere, leaving a residue of pure mercury. Heating a 0.6498 g sample of one of the compounds (Compound I) leaves a residue of 0.6018 g. Heating a 0.4172 g sample of the other compound (Compound II) results in a mass loss of 0.016 g. Determine the empirical formula of each compound. [10 marks]

(b) Draw the structural formulae of the following compounds and identify chiral carbon(s) if any.

(i) 2-bromo-2-ethyl pentane (ii) 3-chloro-2-methyl pentane [4 marks]

(c) The first ionization energies of Period 3 elements are given below:

Na	Mg	Al	Si	P	S	Cl	Ar
496	738	578	789	1012	1000	1251	1521

Identify the orbital from which ionization occurs and explain the trend in the values. [6 marks]

4) (a) Consider the He₂ molecule.

(i) Draw the energy-level diagram of the molecule. [4 marks]

(ii) Write the electron configuration of the He₂ molecule in terms of its MOs. [2 marks]

(iii) What is the bond order in He₂? [2 marks]

(iv) Would you expect the He₂ molecule to be stable or unstable? Explain. [2 marks]

(b) The molecules SiF₄, SF₄ and XeF₄ have the molecular formulas of the type XF₄, but the molecules have different molecular geometries. Predict the shape of each molecule and explain why the shapes differ. [8 marks]

5) a) Define the following types of isomerism encountered in organic compounds, giving examples in each case.

(i) Cis-trans isomerism (ii) Optical isomerism (iii) Structural isomerism [6 marks]

(b) The reaction below can theoretically form two products. Give the structures of the two possible products and explain which product will be predominant.



[4 marks]

(c) In the following molecule, indicate the kind of hybridization you might expect for each numbered carbon atom:



(d) (i) Calculate the mass of AgCl that can be prepared from 20.0 g of AlCl₃ and excess AgNO₃, using this equation: $3 \text{AgNO}_3 + \text{AlCl}_3 \rightarrow 3 \text{AgCl} + \text{Al}(\text{NO}_3)_3$ [4 marks]

(ii) Calculate the mass of excess AgNO₃ remaining after the reaction is complete if 100.0 g were initially added. [3 marks]

*****END OF QUESTION PAPER*****