**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** |

Question paper is approved subject to suggested changes

VS _____ 15/01/2019

## 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) [Ne] $2s^2\ 2p^3$ (iii) [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:

$$Ca_3(PO_4)_2\ (s) + H_2SO_4(aq) \rightarrow CaSO_4(s) + H_3PO_4(aq)$$

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

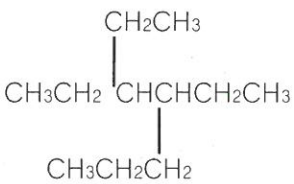
(iii) What mass of $CaSO_4$ is produced from 50 g of $Ca_3(PO_4)_2$ and excess $H_2SO_4$ ?

**[8 marks]**

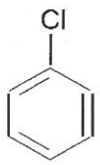
(d) Give the IUPAC names of the following compounds.

(i) $CH_3CHCHCH_2CH_3$

(ii)




(iii)

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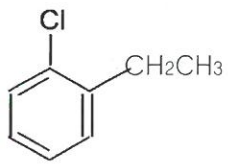


**[4 marks]**

(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 $He_2$ molecule.

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

(ii) Write the electron configuration of the $He_2$ molecule in terms of its MOs. **[2 marks]**

(iii) What is the bond order in $He_2$? **[2 marks]**

(iv) Would you expect the $He_2$ molecule to be stable or unstable? Explain. **[2 marks]**

(b) The molecules $SiF_4$, $SF_4$ and $XeF_4$ have the molecular formulas of the type $XF_4$, 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:

$$^{1}CH_3 - {}^{2}CH = {}^{3}CH - {}^{4}CH_2 - {}^{5}C \equiv {}^{6}CH$$ **[3 marks]**

(d) (i) Calculate the mass of AgCl that can be prepared from 20.0 g of $AlCl_3$ and excess $AgNO_3$, using this equation: $3\ AgNO_3 + AlCl_3 \rightarrow 3\ AgCl + Al(NO_3)_3$ **[4 marks]**

(ii) Calculate the mass of excess $AgNO_3$ remaining after the reaction is complete if 100.0 g were initially added. **[3 marks]**

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