



NATIONAL OPEN UNIVERSITY OF NIGERIA
PLOT 91, CADASTRAL ZONE, NNAMDI AZIKIWE EXPRESSWAY, JABI - ABUJA
FACULTY OF SCIENCES
DEPARTMENT OF PURE & APPLIED SCIENCES
2019_1 EXAMINATION QUESTIONS

CHM 307 ATOMIC AND MOLECULAR STRUCTURE AND SYMMETRY (3 UNITS)

INSTRUCTIONS: ANSWER QUESTION 1 AND ANY FOUR QUESTIONS

TIME ALLOWED 2 ½ HOURS

QUESTION 1

- (ii) State the Pauli's exclusion principle **(3 marks)**
- (ii) Write short note on the following:
 - 1** principles of quantum number **(2 marks)**
 - 2** magnetic quantum number. **(2 marks)**
- (iii) Write short note on the effect of vibration on rotation spectroscopy. **(2 marks)**
- (b)
 - (i) Write short notes on the following:
 - 1. spin-spin coupling. **(2 marks)**
 - 1. orbit-orbit coupling. **(2 marks)**
 - 3. JJ coupling. **(2 marks)**
 - (ii) Discuss two postulates of quantum mechanics. **(4 marks)**
 - (iii) What is a center atom? **(3 marks)**

QUESTION2

- (a) Use the VSEPR theory to deduce the bond angle of the following:
 - 1.** H-C-C bond angle=. **(1 mark)**
 - 2.** H-C=C bond angle=. **(1 mark)**
 - 3.** C=C=C bond angle=. **(1 mark)**
 - 4.** H-N-C bond angle=. **(1 mark)**
 - 5.** C-O-H bond angle=. **(1 mark)**
- (ii) Calculate wave length of 100 ev electron. **(5 marks)**
- (iii) Draw the diagram of energy levels (molecular orbital) in a hydrogen molecule. **(2 marks)**

QUESTION 3

- (a) An electron travels with the speed of $3 \times 10^6 \text{ m s}^{-1}$. What is the minimum uncertainty in its momentum if we assume that its position is measured within 10 % of its atomic radius. Do the same calculation for a 0.03kg ball travelling at a speed of 25 m s^{-1} . Assume that the uncertainty in position of the ball is equal to the wavelength light of 600 nm. **(6 marks)**

- (b) Give the Schrodinger wave equation for 3 dimensional (3D) box. **(1 mark)**
(ii) What are the requirements and principles of rotational spectrum? **(5 marks)**

QUESTION 4

- (a) Using the algebra vector, discuss the vector analogy of a resonance. **(4 marks)**
(ii) highlight on the applications of valence bond theory. **(3 marks)**
(b) Mention four classes of molecules base on their rotational behavior. **(4 marks)**
(ii) Write an expression for orthogonal wave function. **(1 mark)**

QUESTION 5

- (a) Give comparative details of valence bond theory and molecular orbital theory. **(4 marks)**
(ii) Describe the properties of molecular orbitals. **(2 marks)**
(b) Write short note on heat capacity. **(2 mark)**
(ii) Derive an expression for following thermodynamics variables:
1. Heat capacity at constant volume C_v **(2 marks)**
2. Heat capacity at constant volume C_p . **(2 marks)**

QUESTION 6

- (a) Write short note on resonance energy of benzene. **(3 marks)**
(ii) Give the resonance structures of the following:
1. Ozone. **(1 mark)**
2. Alkyl cation. **(1 mark)**
(b) Give the equation for dimensionless heat capacity of a material and what do those materials stand for? **(4 marks)**
(ii) What is molecular orbital? **(3 marks)**