



DEPARTMENT OF CHEMISTRY  
SCHOOL OF PHYSICAL SCIENCES

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

FIRST SEMESTER EXAMINATION 2021/2022 SESSION

COURSE CODE: CHM 413

UNITS: 2

COURSE TITLE: PHYSICAL ORGANIC CHEMISTRY

TIME ALLOWED: 2 HOURS

**INSTRUCTIONS: ANSWER ANY THREE QUESTIONS**

**Q1.** Give details of the bonding interactions and energy diagrams in each of the following molecules:

- (i) Methyl fluoride/Fluoro methane
- (ii) Methanol/ Methyl alcohol
- (iii) Propane (20 marks)

**Q2.** (a). In a tabular form, outline FIVE (5) significant differences between valence bond and molecular orbital theories (5 marks)

b). Consider the following molecules:  $O_2$ ,  $O_2^+$ ,  $O_2^-$ ,  $O_2^{2-}$  and  $O_2^{2+}$

- (i) Justify the existence (or not) of each molecule (6 marks)
- (ii) Arrange them in increasing order of existence (1 mark)
- (iii) Predict the magnetic property of each molecule (2½ marks)
- (iv) Arrange the molecules in decreasing order of bond strength (1 mark)
- (v) Arrange the molecules in increasing order of bond length (1 mark)
- (vi) Arrange the molecules in decreasing order of bond energy (1 mark)

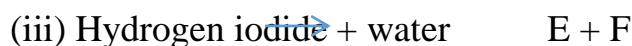
- (vii) Give a detailed molecular orbital picture of the molecule that has the highest probability of existence

**(3 marks)**

- Q3.** (a). On a single diagram, show the bonding interactions, nodes and frontier orbitals in a molecule of Hexa-1, 3, 5-triene

**(10 marks)**

- (b). Give the mechanism of each of the following reactions; indicate the Bronsted/Lewis acid and Bronsted/Lewis base in each case.



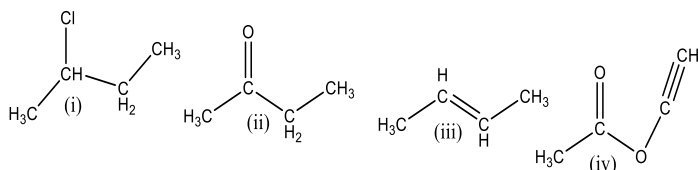
**(10 marks)**

- 4(a)** Define  $sp^2$  hybridization

**(2 Marks)**

- (b). Identify the type of hybridization and shapes of the following functional groups: alcohol, aldehyde, alkyne, amide, carboxylic acid, ester and ether **(5 Marks)**

- (c) Identify and indicate hybridized centres in the following compounds:



**(5 Marks)**

- (d) Draw the three-dimensional structures (p-orbital inclusive) for the hybridized carbons in the following chemical species:

- i. methyl radical ( $\cdot\text{CH}_3$ )
- ii. methyl cation ( $^+\text{CH}_3$ )
- iii. methyl anion ( $^-\text{CH}_3$ )
- iv. Overlap of two methyl radicals ( $\cdot\text{CH}_3$ ) to form ethane and draw its energy diagram.

(8)

**Marks)**

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