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University Examinations 2023/2024

SECOND YEAR SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE AND BACHELOR OF SCIENCE CHEMISTRY

SCH 3250: ATOMIC STRUCTURE AND BONDING

DATE: APRIL 2024 **TIME: 2 HOURS**

INSTRUCTIONS: *Answer question **one** and any other **two** questions*

QUESTION ONE (30 MARKS)

(a) Define the following terms

(i) Bond energy (2 marks)

(ii) Effective nuclear charge (2 marks)

(iii) Bond length (2 marks)

(b) Rank the bonds in each set below in order of decreasing bond length and decreasing bond strength: (3 marks)

i) S—F, S—Br, S—Cl ii) C═O, C—O, C≡O

(c) Max Planck originated the idea that energies can be quantized.

(i) What does the term quantized mean? (2 marks)

(ii) What was Planck trying to explain when he was led to the concept of quantization of energy? (2 marks)

(iii) Give the formula he arrived at and explain each of the terms in the formula. (2 marks)

(d) Predict the geometry of the following molecules or ions, using the VSEPR method:

(4 marks)

(i) NO^{-}_{2}

(ii) $SiCl_4$.

(e) Give the ground-state electron configuration of copper, Z = 29, and draw an orbital-filling diagram, indicating the electrons as up or down arrows. (3 marks)

(f) Which has the larger lattice energy, NaCl or CsI? Explain your choice (2 marks)

(g) Use partial orbital diagrams to describe how mixing the atomic orbitals of the central atom leads to the sp^3d hybrid orbitals in the following: sulfur tetrafluoride, SF_4. (6 marks)

QUESTION TWO (20 MARKS)

(a) Calculate $\Delta H°_{rxn}$ for the chlorination of methane to form chloroform ($CHCl_3$) with bond energies as follows (C−H 413 k/mol, Cl−Cl 243 kJ/mol, C−Cl 339 kJ/mol, Cl−H 427 kJ/mol):

(6 marks)

(b) In your own words, explain the sp^2 hybridization theory (5 marks)

(c) Write the Lewis structure for methanol (molecular formula CH_4O). Show clearly and explain step1, step 2 and step 3 of the process. (5 marks)

(d) Explain the Molecular Orbital Theory (MOT) and state the distingistion between it and the Valence Bond Theory (VBT). (4 marks)

QUESTION THREE (20 MARKS)

(a) Draw a Lewis structure and identify the octet-rule exception for H_3PO_4; draw two resonance forms and select the more important (5 marks).

(b) Using the VSEPR model, draw the molecular shapes and predict the bond angles (relative to the ideal angles) of PF_3 having one lone pair of electrons and belonging to the class AX_3E.

(5 marks)

(c) Use Molecular Orbital (MO) diagrams to find bond orders and predict whether H_2^+ and H_2^- exist. If exists, write its electron configuration in the MO form. (7 marks)

(d) Give the possible combinations of quantum numbers for a 4p orbital. (3 marks)

QUESTION FOUR (20 MARKS)

(a) Using the Ionic Bonding Model, and the trends in lattice energies, discuss how the model explains the following properties of ionic compounds

(i) Physical behavior (3 marks)

(ii) Electrical conductivity (3 marks)

(iii) thermal conductivity (3 marks)

(b) Write resonance structures for the nitrate ion, NO_3^-, and find the bond order. (5 marks)

(c) Write the two resonance structures for ozone molecule and work out the formal charges each atom in both the two resonance structures would have and calculate the actual charge for the molecule. (6 marks)