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University Examinations 2022/2023

SECOND YEAR, SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE (CHEMISTRY), BACHELOR OF EDUCATION SCIENCE

SCH 3250: ATOMIC STRUCTURE AND CHEMICAL BONDING

DATE: APRIL 2023 **TIME:2 HOURS**

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

QUESTION ONE (30 MARKS)

a) Define the following terms

i) Bond order (2 marks)

ii) Effective nuclear charge (2 marks)

iii) First ionization energy (2 marks)

b) Which has the larger radius, N^{3-} or P^{3-}? Explain. (3 marks)

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) With atomic-level views, explain how the ionic bonding model accounts for the following properties of ionic solids: physical behavior, electrical behavior (4 marks)

e) Give the ground-state electron configuration of arsenic, Z = 33 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 (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. Atomic number of Sulphur is 16 (6 marks)

QUESTION TWO (20 MARKS)

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

b) Calculate ΔH^O_{rxn} for the chlorination of methane to form chloroform ($CHCl_3$) with bond energies as follows (C – H 413 k/mol, Cl – Cl 243kJ/mol, C – Cl 339 kJ/mol, Cl – H 427 kJ/mol): (6 marks)

c) Write the Lewis structure for methanol (molecular formula CH_4O). Show clearly and explain step 1, 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)

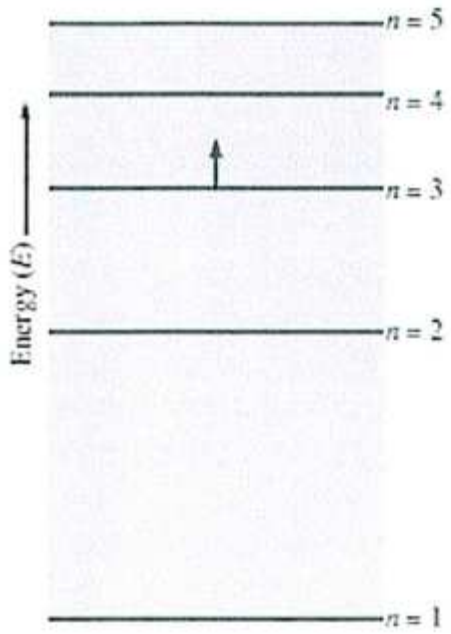
a) Draw a Lewis structure and identify the octet-rule exception for H_3PO_4; draw two resonance forms and select the more important (5 marks)

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 either exists, write its electron configuration in the MO form (10 marks)

QUESTION FOUR (20 MARKS)

a) Given the following energy level diagram for an atom that contains an electron in the *n=3* level, answer the following questions.



(i) Which transition of the electron will emit light of the lowest frequency? (2 marks)

(ii) Using only those levels depicted in the diagram, which transition of the electron would require the highest frequency light? (2 marks)

(iii) If the transition from the *n=3* level to the n=*1* level emits green light, what color light is absorbed when an electron makes the transition from the *n=1* to *n = 3* level? (2 marks)

b) Write resonance structures for the nitrate ion, NO_3^-, and find the bond order. Indicate clearly all the five steps involved (8 marks)

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