



MACHAKOS UNIVERSITY

University Examinations 2017/2018

SCHOOL OF PURE AND APPLIED SCIENCES
DEPARTMENT OF PHYSICAL SCIENCES
SECOND YEAR FIRST SEMESTER EXAMINATION FOR
BACHELOR OF EDUCATION SCIENCE
SCH 200: ATOMIC STRUCTURE AND BONDING

DATE: 18/12/2017

TIME: 8.30-10.30 AM

INSTRUCTIONS:

ANSWER YOUR QUESTIONS IN ANSWER BOOKLET PROVIDED.

ANSWER QUESTION ONE [COMPULSORY] AND ANY OTHER TWO QUESTIONS.

USEFUL CONSTANTS:

$$\epsilon_0 = 8.854 \times 10^{-12} \text{ Fm}^{-1}$$

$$N_0 = 6.023 \times 10^{23} \text{ mol}^{-1}$$

$$1 \text{ eV} = 1.602 \times 10^{-19} \text{ J}$$

$$h = \text{Planck's constant} = 6.626 \times 10^{-34} \text{ J.s}$$

$$m = \text{mass of electron} = 9.1079 \times 10^{-31} \text{ kg}$$

$$e = \text{electronic charge} = 1.602 \times 10^{-19} \text{ C}$$

$$R = 109677.8 \text{ cm}^{-1}.$$

QUESTION ONE (30 MARKS)

- a) Explain what you understand by term 'quantum theory'. (2 marks)
- b) Describe very briefly two experiments that show the dual nature of electromagnetic radiation and at the same time confirm the reliability of Planck's quantum theory. (3 marks)
- c) Calculate the permitted energies of an electron confined in a box 1 Å wide. (3 marks)
- d) Plot the function $\psi_n = \sqrt{\frac{2}{a}} \sin \frac{n\pi}{a} x$ if $n = 6$, $a = 1$, i.e. $0 \leq x \leq 1$ and $\pi = 180^\circ$ (2 marks)
- e) Write Lewis structures of the following compounds:
- i) BaO; ii) Al₂O₃ iii) NH₃ iv) CH₄ (2 marks)
- f) Draw the resonance structure of carbonate ion, CO₃²⁻. (2 marks)
- g) Explain why Phosphorous is able to form pentahalides but nitrogen is not able. (2 marks)
- h) Paramagnetic materials, those with unpaired electrons, are attracted by magnetic fields whereas diamagnetic materials, those with no unpaired electrons, are weakly repelled by such fields. By constructing a molecular orbital picture for each of the following molecules, determine whether it is paramagnetic or diamagnetic. (2 marks)
- i) B₂ ii) C₂ iii) O₂ iv) NO
- i) Predict the hybridization of the central atom in each of the following molecules. (1.5 marks)
- i) CH₄ ii) HCCCH iii) CH₂O
- j) Lattice energies cannot be measured directly but experimental values are obtained from thermodynamic data using the Born-Haber cycle. Theoretical values can be calculated using the **Born-Lande** equation shown as follows. Define all terms in this equation.
- $$U = -\frac{N_o A z^+ z^- e^2}{4\pi\epsilon_o r_o} \left(1 - \frac{1}{n}\right)$$
- (2.5 marks)
- k) The following figure shows a Born-Haber cycle for the formation of NaCl. Calculate the lattice energy of formation (2 marks)
- l) Using an example, describe hydrogen bonding in polar molecules (2 marks)
- m) Define the term Bond Order (2 marks)
- n) Using an appropriate diagram distinguish between constructive interference and destructive interference (2 marks)

QUESTION TWO (20 MARKS)

- a) With relevant equations and examples, discuss the nature of the a chemical bond according to the Valence Bond Theory (10 marks)
- b) Using relevant examples describe Sp^3 , Sp^2 , Sp and Sp^3d hybrid orbitals (10 marks)

QUESTION THREE (20 MARKS)

- a) Write down the simple and long form of the Schrodinger Equation and state its FIVE major solutions (10 marks)
- b) Describe the Bohr Model of the Atom (1913) and derive the equation *radius of each orbit in Bohr's model given by;*

$$r = \frac{n^2 h^2 \epsilon_o}{\pi m e^2}$$

(10 marks)

QUESTION FOUR (20 MARKS)

- a) Describe the periodic trends of the following atomic parameters (10 marks)
- Effective nuclear charge,
 - Atomic radii,
 - First ionization energies,
 - Electron affinity
 - Electronegativity
- b) Discuss the applications of the Radial distribution function $4\pi r^2 R(r)$ and the Radial wavefunction $R(r)$ in describing atomic properties (10 marks)

QUESTION FIVE (20 MARKS)

- a) Express the Linear Combination of Atomic Orbitals (LCAO) theory equation and describe in details the rules and procedure used to construct molecular orbitals (10 marks)
- b) Draw orbital correlation diagrams for hypothetical H-H and He-He molecules (10 marks)