MACHAKOS UNIVERSITY

University Examinations 2020/2021

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PYSICAL SCIENCES

SECOND YEAR SUPPLEMENTARY/SPECIAL EXAMINATION FOR

BACHELOR OF SCIENCE (APPLIED PHYSICS AND TECHNOLOGY)

BACHELOR OF SCIENCE (ANALYTICAL CHEMISTRY)

BACHELOR OF EDUCATION (SPECIAL NEEDS)

BACHELOR OF EDUCATION (SCIENCE)

BACHELOR OF SCIENCE (MATHEMATICS)

SCH 200: ATOMIC STRUCTURE AND CHEMICAL BONDING

DATE: 16/03/2022 **TIME 2:00PM – 4.00 PM**

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks)

Required data and constants:

Planck's constant = 6.623 × 10^{-34} J.S
Electron mass = 9.1 ×10^{-31} Kg
1Ev = 1.602 ×10^{-19}J
1M = 10^{10} Å
Atomic numbers Be =4, F=9, Mg = 12, Cl = 17, O = 8, C = 6, N = 7, B = 5, Ni = 28

SECTION A

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Define the term quantum number (2 marks)

b) State and explain the four quantum numbers that define an electron in a particular orbital. (4 marks)

c) Write the electron configuration of a nitrogen atom and hence assign quantum numbers to each of the seven electrons in the orbitals. (7 marks)

d) Calculate the zero-point energy of an electron confined in a box 1.0 Å wide. (4 marks)

e) Define a chemical bond and differentiate between covalent and ionic bonding using the lewis structures of both magnesium chloride and hydrogen chloride. (3 marks)

f) Using benzene molecule as an example explain what is meant by resonance structures. (3 marks)

g) What is sp hybridization? Using gaseous beryllium fluoride molecule, explain how the central atom forms sp hybrid orbitals. (3 marks)

h) Define the term polarization as used in ionic compounds (2 marks)

i) Explain why the theoretical lattice energy of lithium chloride is greater than that of sodium chloride. (2 marks)

SECTION B

QUESTION TWO (20 MARKS)

a) What is hydrogen like atoms resulting from the chemical ionization process? List three examples. (2 marks)

b) What is the difference between the energy levels of hydrogen atom and those of Multi electron atoms? (2 marks)

c) If an electron has quantum numbers n =2, l = 0 and $m_l = 0$ and $m_s = +½$ what atomic orbital is it occupying? (2 marks)

d) Write down the other possible set of quantum numbers for another electron in the orbital identified in 2 (c) above. (2 marks)

e) Write down six possible sets of quantum numbers that describe an electron in a 2p atomic orbital. What is the physical significance of these unique sets? (6 marks)

f) Define the term shielding. (2 marks)

g) Calculate the effective nuclear charge on a 3d electron in a nickel atom (4 marks)

QUESTION THREE (20 MARKS)

a) Explain the following trends in relation to the periodic table.

i. Across the period, the atomic radii decreases while down the group atomic radii increase. (2 marks)

ii. The ionic radius of Na^+ is smaller than that of K^+ (2 marks)

b) Explain how a covalent bond is formed according to valence bond theory (VBT). (3 marks)

c) What determines the strength of a covalent bond according to VBT? (1 mark)

d) Using suitable atomic orbitals explain how bonding occurs in the following molecules according to VBT:

i. Hydrogen molecule (2 marks)

ii. Chlorine molecule (2 marks)

iii. Hydrogen fluoride molecule (2 marks)

e) Predict the hybridization of the central atom in each of the following species. Explain your answer.

i. $CH_2{=}CH_2$ (2 marks)

ii. $CH{\equiv}CH$ (2 marks)

iii. C_2H_6 (2 marks)

QUESTION FOUR (20 MARKS)

a) Define the term delocalized electrons (2 marks)

b) Draw the resonance structures of the following:

i. O_3 (2 marks)

ii. NO_3^- (3 marks)

c) What conclusion can you make about the net bonding picture in Ozone? (2 marks)

d) By constructing a molecular orbital energy picture for each of the following molecules, determine whether the molecule is paramagnetic or diamagnetic.

i. B_2 (2 marks)

ii. F_2 (3 marks)

iii. C_2 (3 marks)

e) Calculate the bond order for each molecule. (3 marks)

QUESTION FIVE (20 MARKS)

a) Define the following terms:

   i. Lattice energy (2 marks)

   ii. Hydration energy (2 marks)

b) Explain why the ionization energy of K^+ is greater than that of K (2 marks)

c) The born-haber-cycle lattice energies in kJ /mol for LiCl, NaCl, and KCl decrease in the order-817, -764 and -679 respectively. Explain this trend. (3 marks)

d) Describe the usefulness of lattice energies (3 marks)

e) Given the following information,

   Enthalpy of sublimation for solid lithium = 161 kJ/mol

   First ionization energy for solid lithium = 520 kJ/mol

   F-F bond dissociation energy = 154 kJ/mol

   Enthalpy of formation of F(g) = 77 kJ/ mol

   Electron affinity for fluorine = -328 kJ/mol

   Enthalpy of formation for solid lithium fluoride = -617 kJ/mol

   i. Draw a Born-Haber cycle for the formation of solid lithium fluoride. (4 marks)

   ii. From your cycle, calculate the lattice enthalpy for lithium fluoride. (4 marks)