# MACHAKOS UNIVERSITY

**University Examinations 2019/2020Academic year**

**SCHOOL OF PURE AND APPLIED SCIENCES**

**DEPARTMENT OF PHYSICAL SCIENCES**

**SECOND YEAR FIRST SEMESTER EXAMINATION FOR**

**BACHELOR OF SCIENCE IN ANALYTICAL CHEMISTRY**

**BACHELOR OF EDUCATION (SPECIAL EDUCATION)**

**BACHELOR OF SCIENCE (MATHEMATICS)**

**BACHELOR OF EDUCATION (SCIENCE)**

**BACHELOR OF SCIENCE (BIOLOGY)**

**SCH 200: ATOMIC STRUCTURE AND CHEMICAL BONDING**

**DATE: 5/12/2019** **TIME: 8.30-10.30 AM**

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**INSTRUCTIONS TO CANDIDATES**

- 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* = $6.623 \times 10^{-34}$ *J.S*

*Electron mass* = $9.1 \times 10^{-31}$ *Kg*

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

*Atomic numbers Be =4, F=9, Mg = 12, Cl = 17, O = 8, C = 6, N = 7, B = 5*

**SECTION A**

**QUESTION ONE (30 MARKS)**

a) State the Heisenberg uncertainty principle. (1 mark)

b) What are the consequences of the Heisenberg uncertainty principle in the understanding of matter? (2 marks)

c) Write down the time independent schrodinger equation for the motion of a particle of mass **m** along the x-axis (2 marks)

d) Supposing the particle in 1 (c) above is bouncing back and forth between the walls of a one-dimensional box with its wave motion along the x-axis between x = 0 and x = a without loss of energy. Show that its allowed energies are given by: (7 marks)

$$E_n = \frac{n^2h^2}{8ma^2}$$

e) Calculate the zero point energy of an electron confined in a box $1.2A^0$ wide. (2 marks)

f) i What is a chemical bond? (1 mark)

ii Differentiate between covalent and ionic bonding using the lewis structures of both magnesium chloride and hydrogen chloride. (2 marks)

g) Using ozone molecule as an example explain what is meant by resonance structures. (2 marks)

h) i What is sp hybridization? (1 mark)

ii Using gaseous beryllium fluoride molecule, explain how the central atom forms sp hybrid orbitals. (2 marks)

i) i What is a paramagnetic molecule? (1 mark)

ii By constructing a molecular orbital picture of oxygen molecule, show that the molecule is paramagnetic. (3 marks)

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

k) 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) i What are hydrogen like atoms? (1 mark)

ii List three examples. (1 mark)

b) Solution to the Schrödinger equation for hydrogen atoms involves solving three functions separately to obtain three quantum numbers **n, l,** and **ml**. How do the quantum numbers arise for an electron in hydrogen atom of the quantum numbers. (2 marks)

c) What is their significance in describing the wave function? (2 marks)

d) If an electron has quantum numbers n =2, l = 0 and ml = 0 and ms = +½ which type of atomic orbital is it occupying? (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? (3 marks)

f) Differentiate between Hund's rule and Pauli exclusion principles (2 marks)

g) i) Elements X and Y have atomic numbers 14 and 79 respectively. Write down the electron configurations of X and Y. (2 marks)

ii) State the group and period that the elements in g(i) above belong? Show your working. (2 marks)

h) i) The effective nuclear charge in the 1s, 2s and 2p orbitals of boron changes in the order 4.68, 2.58 and 2.42 respectively. Explain this observation. (2 marks)

ii) How does the change in effective nuclear charge influence the sizes of boron orbitals? (1 mark)

**QUESTION THREE (20 MARKS)**

a) Explain the following trends:

i. Across a certain period, the atomic radii decreases while down a certain group atomic radii increases. (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

i. $CH_2CH_2$ (2 marks)

ii. CHCH (2 marks)

iii. $C_2H_6$ (2 marks)

**QUESTION FOUR (20 MARKS)**

a) Define the following terms

i. Localised electrons (1 mark)

ii. Delocalised electrons (1 mark)

b) Draw the resonance structures of the following:

i. Benzene (2 marks)

ii. $NO_3^-$ (3 marks)

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

d) By constructing a molecular orbital picture for each of the following molecules, determine whether it 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 in (d) above. (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, draw a Born-Haber cycle for the formation of solid lithium fluoride.

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 (4 marks)

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