MACHAKOS UNIVERSITY

University Examinations 2016/2017

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

SECOND YEAR APRIL SESSION EXAMINATION FOR BACHELOR OF EDUCATION

SCH 200: ATOMIC STRUCTURE AND CHEMICAL BONDING

DATE: SCHOOL BASED **TIME:**

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*

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

SECTION A

1. a) Consider a particle that is undergoing simple harmonic wave like motion in one dimension with the wave propagation along x axis. The general equation for the wave is:

$\mu = \frac{Asin2\pi x}{\lambda}$ where A is the amplitude of the wave.

Find $\frac{d\mu}{dx}$ and hence show that $\frac{d\mu^2}{dX^2} = -4\pi^2\mu/\lambda^2$ (4 marks)

b) If the particle is in a box, it is of mass m and moves with a velocity **v,** what is the kinetic energy, KE? (2 marks)

c) Using the de-Broglie equation, derive the schrodinger equation for the wave motion in the x axis. (3 marks)

d) Calculate the permitted energies of an electron confined in a box 1.2**Å**wide. (3 marks)

e) For a neutral atom X, arrange the following atomic orbitals in order of their increasing energies (not all orbitals are listed). (3 marks)

2s, 3s, 6s, 4p, 3p,3d, 6p, 1s

f) Use VB theory and lewis structure model to determine the bond order in:

i. H_2 (2 marks)

ii. Na_2 (2 marks)

g) How many radial nodes does each of the following orbitals posess?

i. 2s (1 mark)

ii. 3p (2 marks)

h) comment on the differences between plots of R(r) against r and $4\pi r^2Rr^2$ against r for each of the following atomic orbitals.

i. 1s (2 marks)

ii. 3p (2 marks)

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

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

SECTION B: ANSWER ANY OTHER TWO QUESTIONS

2. a) What are hydrogen like atoms? List three examples. (3 marks)

b) Solution to the schrodinger 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? (2 marks)

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

d) If an electron has quantum numbers n =2, l = 1 and ml = -1 and ms = +½ which type of atomic orbital is it occupying? (2 marks)

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

f) Differentiate between Aufbau and Pauli exclusion principles (2 marks)

g) Elements X and Y have atomic numbers 13 and 82 respectively. Write down the electron configurations of X and Y. (2 marks)

h) State the group and period that the elements belong? Show your working. 2 marks.

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)

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

3. 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^+ ($2s^2sp^6$) is greater than that of Mg^{2+} ($2s^22p^6$) (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? 1mk

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

i. Hydrogen molecule 2 marks

ii. Fluorine molecule 2 marks

iii. Hydrogen chloride molecule 2 marks

e) Predict the hybridization of the central atom in each of the following species

i. HCCH (2 marks)

ii. BF_3 (2 marks)

iii. PF_5 (2 marks)

4. 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 (3 marks)

5. a) Define the following terms:

i. Lattice energy (1 mark)

ii. Ionization energy (1 mark)

iii. Electron affinity (1 mark)

iv. Hydration energy (2 marks)

b) Explain why the ionization energy of Mg^{2+} is less than that of Mg^{3+} (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. (3 marks)