MACHAKOS UNIVERSITY

University Examinations 2018/2019

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

SECOND YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (MECHANICAL, CIVIL AND ELECTRICAL ENGINEERING)

ECU 100: CHEMISTRY FOR ENGINEERS I

DATE: 27/9/2019 **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:

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

$No = 6.023 \times 10^{23}\ mol^{-1}$

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

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

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

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

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

QUESTION ONE (THIRTY MARKS)

a. Draw the shapes of various d-orbitals (4 marks)

b. State the set of rules used in guiding the filling order of orbitals. (4 marks)

c. Elements X and Y (not their actual symbols) have atomic number 13 and 82 respectively. Write down their electron configurations. To which period and groups do they belong? (4 marks)

d. Define the term shielding (2 marks)

e. Define the term buffer solution. Give an example (4 marks)

f. The half-life of a radioactive element is 30 days. Calculate the time required for its activity measured with G. M counter to drop from 4800 counts per minute to 300 counts per minute (ignore background counts). (4 marks)

g. Calculate the frequency and wavelength of the emitted photon when electron drops from the n=5 to the n=2 level in a hydrogen atom (4 marks)

h. Define hybridization and show how sp3 hybridization occurs in ethane (4 marks)

QUESTION TWO (TWENTY MARKS)

a) Outline the limitations of the Bohr Model (3 marks)

b) Write down the expressions for calculation of the energy in an electron at a given n level in a hydrogen atom, to obtain Joules and electron Volts (eV) (3 marks)

c) Discuss the applications of the radial distribution function $4\pi r^2 R(r)$ and the radial wavefunction R(r) in describing atomic properties (5 marks)

d) Using relevant examples describe sp^2, sp and sp^3d hybrid orbitals (9 marks)

QUESTION THREE (TWENTY MARKS)

a) Describe the experimental basis for believing that the nucleus occupies a very small fraction of the volume of the atom (5 marks)

b) Derive the Louis de Broglie equation and state the explanations given to the questions arising from the postulates in the Bohr atom that restricted electrons to orbiting the nucleus at fixed distances (5 marks)

c) Calculate Z_{eff} for the following (4 marks)

i. a 3d electron in a Nickel atom (Z=28)

ii. outermost electron in Fluorine (Z=9)

d) Using relevant examples, show how the following molecular geometries are formed (6 marks)

i. Trigonal planar

ii. Tetrahedral

QUESTION FOUR (TWENTY MARKS)

a. Write short notes on the following concepts. Explain the general trends of each of them among elements found in the modern periodic table (8 marks)

i. Covalent radius

ii. Van der waal radius

iii. Ionic radius

b. Describe in detail the following Periodic Trends of elements (12 marks)

i. Effective nuclear charge,

ii. First ionization energies,

iii. Electron affinity

iv. Electronegativity

QUESTION FIVE (TWENTY MARKS)

a) Derive the Henderson-Hasselbalch Equation. What is the pH a buffer solution made from 0.1 M acetic acid and 0.1 M sodium acetate solution, given Ka (acetic acid = 1.8×10^{-5}M) (8 marks)

b) Derive the following expressions (6 marks)

i. $$E_n = -\frac{Z^2 me^4}{8h^2\varepsilon_0^2}\frac{1}{n^2}$$

ii. $$\frac{\ln 2}{k} = t_{1/2}$$

c) Describe the 3 types of radioactive isotopes and discuss their uses (6 marks)