



MACHAKOS UNIVERSITY

University Examinations 2019/2020 Academic year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR FIRST SEMESTER EXAMINATION FOR
BACHELOR OF SCIENCE (ELECTRICAL ENGINEERING)
BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)
BACHELOR OF SCIENCE (CIVIL ENGINEERING)

ECU 100: CHEMISTRY FOR ENGINEERS 1

DATE: 13/12/2019

TIME: 2.00-4.00 PM

INSTRUCTIONS TO CANDIDATES

- The paper consists of **two** sections
- Section A is **compulsory**.
- Answer any **two** questions from section B

Some useful information

Speed of light $c = 2.997926 \times 10^8 \text{ ms}^{-1}$ Avogadro constant $N_A = 6.022045 \times 10^{23} \text{ mol}^{-1}$

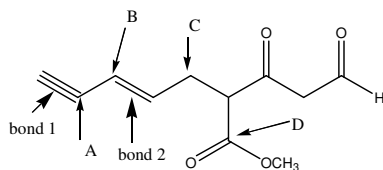
Plank's constant $h = 6.626176 \times 10^{-34} \text{ J s}$ $1 \text{ nm} = 1 \times 10^{-9} \text{ m}$

SECTION A – COMPULSORY

QUESTION ONE (30 MARKS)

- a) Explain the following terminologies usually encountered in chemistry: (4 marks)
- Electronegativity
 - Atomic orbitals
 - Planck's quantum theory
 - Heisenberg uncertainty principle
- b) Briefly explain the trend in ionization energy across period 2 and outline the two anomalies in the general trend (6 marks)

- c) Use the structure below to answer the questions that follow



- i. What is the hybridization of the carbons indicated by arrows A to D (2 marks)
 - ii. By redrawing the molecule identify an ester, ketone, aldehyde and alkyne functional groups in the molecule (2 marks)
 - iii. Explain which between bond 1 and bond 2 is longer (2 marks)
- d) Which of the following sets of quantum numbers are unacceptable? Explain yours answers.
- i) (2, 0, 1/2, -1/2) ii) (3, 2, 0, +1/2) iii) (2, 2, 1, +1/2) (2 marks)
- e) Give the values of the quantum numbers associated with the following orbitals:
- i) 3s ii) 4f (2 marks)
- f) An atom has an atomic number 32, by writing its electronic configuration, determine its group and period (3 marks)
- g) Using the concept of hybridization explain the bonding in benzene, clearly showing all the pi bonds (4 marks)
- h) Three different alkenes yield 2-methylbutane when they are hydrogenated in presence of metal catalyst. Draw the structures of the three alkenes (3 marks)

SECTION B: ANSWER ANY TWO QUESTIONS

QUESTION TWO (20 MARKS)

- a) A certain metal has a work function of $3.06 \times 10^{-19} \text{ J}$. A light of wavelength of 450nm shines on the surface of the metal, calculate:
- i. The threshold frequency of the light (2 marks)
 - ii. The kinetic energy in Joules of the electron (3 marks)
 - iii. Speed of the electron (2 marks)
- b) How does Bohr's theory of an atomic structure differ from Thomson's plum pudding atomic model (3 marks)
- c) Calculate the *de Broglie* wavelength (in nanometers) associated with a beam of neutrons moving at a speed of $2.0 \times 10^7 \text{ m/s}$. (mass of a neutron = $1.67495 \times 10^{-24} \text{ g}$) (2 marks)
- d) The change in energy in a hydrogen atom, ΔE , in electronic transition is given by:

$$\Delta E = 2.18 \times 10^{-18} \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right) \text{ Joules}$$

Determine the energy for the transition $n=2$ to $n=9$ (2 marks)

- e) Sketch the shapes of orbitals for which $l = 1$: (3 marks)
- f) It is observed that ketones have higher boiling points than alkanes of comparable molecular weight while alcohols have higher boiling point than ketones of comparable molecular weight, explain these observations (3 marks)

QUESTION THREE (20 MARKS)

- a) Explain the differences between chemical and nuclear reactions (2 marks)
- b) Complete the following nuclear reactions and identify X and Y (2 marks)
- i) ${}_{12}^{26}\text{Mg} + {}_1^1\text{p} \rightarrow \text{X} + {}_2^4\text{He}$
- ii) ${}_{8}^{20}\text{O} \rightarrow {}_9^{20}\text{Ca} + \text{Y}$
- c) Indicate the oxidation number of the underlined atoms in each of the following species:
- i. $\text{H}\underline{\text{C}}\text{lO}_4$
- ii. $\underline{\text{S}}\text{O}_3^{-2}$ (2 marks)
- d) Using the VSEPR determine the geometry / shape of the following molecules:
- i. CS_2
- ii. NH_3
- iii. SF_4 (6 marks)
- e) Using a schematic diagram explain the observations and conclusions made by Ernest Rutherford in his planetary model of an atom (5 marks)
- f) Draw the correct structure for each of the following molecules
- i. 3-butyne-2-ol
- ii. 2-chloro-3-hexanone
- iii. Cis-but-2-ene (3 marks)

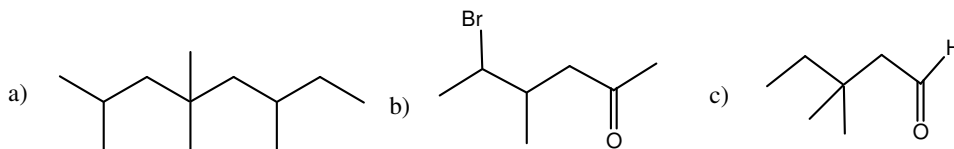
QUESTION FOUR (20 MARKS)

- a) Explain why H_2O is a liquid while H_2S is a gas even though sulfur and oxygen belong to the same group (2 marks)
- b) Draw Lewis structures for: (2 marks)
- i. NO
- ii. Mg_3N_2
- c) Write the electron configuration of the following species:
- i. W ($z=74$) (2 marks)
- ii. Ru^{+3} ($z=44$) (2 marks)

- iii. Ag ($z=47$) (2 marks)
- d) Balmer series is one of the series in the atomic spectrum of hydrogen atom, it involves transition from $n_2 = (3,4,5,6\dots)$ to $n_1=2$. Name the other 4 series in the hydrogen atomic spectra and the transitions involved (4 marks)
- e) A 0.128 g sample of Potassium hydrogen phthalate ($\text{HKC}_8\text{H}_4\text{O}_4$) required 28.54 cm^3 of NaOH solution to reach a phenolphthalein end point. (Given $\text{H}=1.008$, $\text{K}=39.098$ and $\text{O}=19.999$)
- Write ionic equation for the reaction (1 mark)
 - Calculate the number of moles of Potassium hydrogen phthalate in 0.0128 g Sample (2 marks)
 - Calculate the molarity of the NaOH. (3 marks)

QUESTION FIVE (20 MARKS)

- a) Each atomic orbital (Ψ) may be uniquely defined by a set of three quantum numbers, Give these quantum numbers and the kind of information obtained from these quantum numbers. (6 marks)
- b) By use of a general scheme show how an ester can be synthesized from a terminal alkene (clearly show all the intermediates, specific reagents are not necessary) (5 marks)
- c) Write the correct IUPAC names of the following compounds (3 marks)



- d) Explain the following observations in the periodic table:
- Atomic radius decreases across the period (from left to right) (2 marks)
 - Covalent radius for sodium is longer than ionic radius (2 marks)
 - Ionic radius for alkali metals decreases down the group (2 marks)