



MACHAKOS UNIVERSITY

University Examinations for 2019/2020 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR
BACHELOR OF SCIENCE (ELECTRIC AND ELECTRONICS ENGINEERING)

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

BACHELOR OF SCIENCE (CIVIL ENGINEERING)

ECU 100: CHEMISTRY FOR ENGINEERS I

DATE: 12/8/2021

TIME: 2:00 – 4:00 PM

INSTRUCTIONS:

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

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 $h = 6.626176 \times 10^{-34} \text{ J s}$	$1 \text{ nm} = 1 \times 10^{-9} \text{ m}$
Gas constant, $R = 8.314 \text{ JK}^{-1} \text{ mol}^{-1} = 0.08206 \text{ L atm K}^{-1} \text{ mol}^{-1}$	$1 \text{ atm} = 760 \text{ mmHg} = 101325 \text{ Nm}^{-2}$

SECTION A - COMPULSORY

QUESTION ONE (30 MARKS)

- (a) Classify the following sets of quantum numbers as either acceptable or unacceptable?
Explain yours answers.

- (3, 0, 0, $-\frac{1}{2}$)
- (3, 2, 0, $-\frac{1}{2}$)
- (2, 2, 1, $+\frac{1}{2}$)
- (3, 2, -3, $+\frac{1}{2}$)

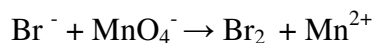
(4 marks)

- (b) Explain the following: (4 marks)
- Atomic radius decreases from left to right across period (2) elements
 - Atomic sizes of group (1) elements decrease down the group
- (c) Explain the difference between electron affinity and ionization energy (2 marks)
- (d) A sample of 0.5 moles of NH_3 gas occupies 0.5 L at 0°C . Calculate the pressure of the gas (in atm) using the:
- Ideal gas equation (2 marks)
 - Van der Waals equation given $a = 6.58 \text{ L}^2 \text{ atm mol}^{-2}$ and $b = 0.056 \text{ L mol}^{-2}$ (3 marks)
- (e) Briefly explain the key observations and conclusions from Rutherford scattering experiment (4 marks)
- (f) Chromium metal has a binding energy of $7.1 \times 10^{-19} \text{ J}$ for certain electrons. Calculate the photon frequency needed to eject electrons from chromium metal with $2.2 \times 10^{-19} \text{ J}$ of kinetic energy? (4 marks)
- (g) Explain the following terminologies usually encountered in chemistry:
- Electromagnetic radiation (1 mark)
 - Wave- particle duality (1 mark)
 - Planck's Quantum Theory (1 mark)
 - Heisenberg's uncertainty principle (1 mark)
- (h) An element X (not its actual symbol) has an atomic number 52. To which period and group of the periodic table does it belong? (3 marks)

SECTION B: ANSWER ANY TWO QUESTIONS

QUESTION TWO (20 MARKS)

- (a) With explanations, arrange the following ions in increasing ionic radius Na^+ , Mg^{2+} , F^- , N^{3-} , O^{2-} (2 marks)
- (b) Use the reaction below to answer the questions that follow
- (i) Balance the redox reaction below using the half reaction method (4 marks)



- (ii) Identify the oxidizing agent and reducing agent (2 marks)
- (c) Explain the following observation: (4 marks)
- The first ionization energy of phosphorous is higher than that of Sulphur
 - The first ionization energy of magnesium is higher than that of aluminum
- (d) Determine the values of the quantum numbers associated with the following orbitals:
- 3p (2 marks)
 - 4s (2 marks)
- (e) (i) Explain the term hybrid orbitals (1 mark)
- (ii) Use the concept of hybrid orbitals to explain the bonding in ethene molecule using a well labeled valence bond theory structure (4 marks)

QUESTION THREE (20 MARKS)

- a) i) State Dalton's Law of partial pressures (1 mark)
- ii) 100 cm³ of oxygen gas at 1.75 atm and 200 cm³ of nitrogen gas at 0.6 atm are passed into a 500 cm³ vessel. Compute the total pressure of the gas mixture in the vessel at the same temperature (4 marks)
- b) Camphor is composed of 78.90% C and 10.51% O. The remainder is H. What is its empirical formula? (3 marks)
- c) Calculate the *de Broglie* wavelength (in nanometers) associated with beam of neutrons moving at a speed of 2.0×10^{10} m/s. (mass of a neutron = 1.67495×10^{-24} g) (2 marks)
- d) A 0.128 g sample of Potassium hydrogen phthalate (HKC₈H₄O₄) required 28.54 cm⁻³ of NaOH solution to reach a phenolphthalein end point.
- Write ionic equation for the reaction (1 mark)
 - Calculate the number of moles of Potassium hydrogen phthalate in 0.0128 g sample. (2 marks)
(Given H=1.008, K=39.098 and O=19.999)
 - Calculate the molarity of the NaOH. (2 marks)
- e) The red light has a wavelength of about 200 nm. Calculate the energy in Joules of one mole of photons associated with this wavelength (2 marks)
- f) Sketch any two orbitals for which $l = 1$: (2 marks)

QUESTION FOUR (20 MARKS)

- (a) Briefly explain the observation of the photoelectric effect and how it supports the quantum theory (5 marks)
- (b) 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)
- (c) Write the electron configuration of the following species:
- | | | | |
|------|-----------|------------|-----------|
| i) | S^{2-} | ($z=16$) | (2 marks) |
| ii) | Ru^{+3} | ($z=44$) | (2 marks) |
| iii) | Fe^{2+} | ($z=26$) | (2 marks) |
- (d) A balloon has a volume of 31,150 L, If the temperature of its surroundings is 30°C and the atmospheric pressure is 745 mmHg, how many moles of hydrogen gas are needed to fill this balloon? (2 marks)
- (e) Draw the Lewis structure of the following compounds:
- | | | | |
|------------------|-----------------------------|-------------------|-----------|
| i) CO_2 | ii) Mg_3N_2 | iii) N_2 | (3 marks) |
|------------------|-----------------------------|-------------------|-----------|

QUESTION FIVE (20 MARKS)

- (a) Determine the oxidation state of nitrogen and phosphorus in ammonium dihydrogen phosphate ($\text{NH}_4\text{H}_2\text{PO}_4$)? (3 marks)
- (b) Each atomic orbital (Ψ) may be uniquely defined by a set of four quantum numbers. Name these quantum numbers and the kind of information they provide (8 marks)
- (c) Using the VSEPR, illustrate the geometry / shape of the following molecules:
- | | | | |
|------------------|-------------------|---------------------|-----------|
| i) CO_2 | ii) NF_3 | iii) CCl_4 | (3 marks) |
|------------------|-------------------|---------------------|-----------|
- (d) The rate of diffusion of O_2 is 0.6 litres /sec. Given that the vapour density of gas X is 14, calculate the rate of diffusion for gas X. (3 marks)
- (e) One type of anaerobic respiration converts glucose ($\text{C}_6\text{H}_{12}\text{O}_6$) to ethanol ($\text{C}_2\text{H}_5\text{OH}$) and carbon dioxide. If the molecular weight of glucose is 180 grams/mol and the molar mass of ethanol is 46g/mol, how many grams of carbon dioxide are produced when 1 mol of glucose is digested via respiration? (3 marks)