MACHAKOS UNIVERSITY

University Examinations for 2021/2022 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRIC AND ELECTRONIC ENGINEERING)

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

BACHELOR OF SCIENCE (CIVIL ENGINEERING)

ECU 100: CHEMISTRY FOR ENGINEERS I

DATE: 27/1/2022 **TIME: 11.00-1.00 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 $c = 2.997926x10^{8}$ ms^{-1}	Avogadro constant $N_A = 6.022045x10^{23}$ mol^{-1}
Plank's constant $h = 6.626176x10^{-34}$ J s	$1nm = 1x10^{-9}m$
Gas constant, R = 8.314 $JK^{-1}mol^{-1}$ = 0.08206 L atm K^{-1} mol^{-1}	1 atm = 760 mmHg = 101325 Nm^{-2}
1 eV = $1.602176634\times10^{-19}$	Mass of the electron = 9.11 x 10^{-31} Kg

SECTION A - COMPULSORY

QUESTION ONE (30 MARKS)

a) Determine the values of the quantum numbers associated with the following orbitals:

i. $2p$ (2 marks)

ii. $3s$ (2 marks)

b) Classify the following sets of quantum numbers as either acceptable or unacceptable. Explain yours answers. (4 marks)

i. (4, 0, 0, -½)

ii. (4, 2, 0, -½)

iii. (2, 2, 1, -½)

iv. (3, 2, -3, -½)

c) Explain the following: (4 marks)

i. Ionic sizes of group (2) elements decrease down the group

ii. Atomic sizes decreases from left to right across period (3) elements

d) With explanations, arrange the following ions in increasing ionic radius Mg^{2+}, F^{-}, N^{3-}, O^{2-} and Na^{+} (2 marks)

e) i. Explain the term hybrid orbitals (1 mark)

ii. Use the concept of hybrid orbitals to explain the bonding in ethyne molecule using a well labeled valence bond theory structure (4 marks)

f) Briefly describe Bohr's theory of the hydrogen atom and its failures (5 marks)

g) The work function of potassium metal is 2eV. If a light with a wavelength of 425 nm shines on the metal, calculate the speed of the ejected electron. (6 marks)

SECTION B: ANSWER ANY TWO QUESTIONS

QUESTION TWO (20 MARKS)

a) Explain the difference between electronegativity and electron affinity (2 marks)

b) Balance the redox reaction below using the half reaction method (6 marks)

$$MnO_4^-{}_{(aq)} + I^-_{(aq)} \longrightarrow Mn^{2+}_{(aq)} + I_{2(aq)}$$

c) Explain the following terminologies usually encountered in chemistry:

i. Atomic orbital (1 mark)

ii. Planck's Quantum Theory (1 mark)

iii. Wave- particle duality (1 mark)

c) Briefly explain the key observations and conclusions from Rutherford scattering experiment. (4 marks)

d) i. State Dalton's Law of partial pressures (1 mark)

ii. A metal can of volume 2000.0 cm^3 contains 2.0 g of nitrogen gas and 6.0 g of hydrogen gas at exactly 200 ^oC. Calculate the total pressure of gas in the can. (RAM N=14, H=1) (4 marks)

QUESTION THREE (20 MARKS)

a) Determine the oxidation state of nitrogen and phosphorus in ammonium dihydrogen phosphate

b) ($NH_4H_2PO_4$). (2 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) Each atomic orbital (Ψ) may be uniquely defined by a set of four quantum number. Name these quantum numbers and the kind of information they provide (6 marks)

e) Write the electron configuration of the following species:

i. Se^{2-} (z=34) (2 marks)

ii. Ru^{+3} (z=44) (2 marks)

iii. Mn^{2+} (z=25) (2 marks)

f) An element X (not its actual symbol) has an atomic number 40. To which period and group of the periodic table does it belong? (3 marks)

QUESTION FOUR (20 MARKS)

a) i. State the Gay-Lussac's law (1 mark)

ii. A jar containing 1.12 litres of oxygen has a pressure of 754 mmHg at 30^oC and a mass of 1.43 g. Calculate the volume occupied by 32.0 g of oxygen at STP. (3 marks)

b) Briefly explain the observation of the photoelectric effect and how it supports the quantum theory (5 marks)

c) A type of anaerobic respiration converts glucose ($C_6H_{12}O_6$) to ethanol (C_2H_5OH) and carbon dioxide. If the molecular weight of glucose is 180 grams/mol and the molar mass of ethanol

is 46g/mol. Calculate the grams of carbon dioxide produced when 2 mol of glucose is digested via respiration? (3 marks)

d) Vitamin C (ascorbic acid) contains 40.92 % C, 4.58 % H, and 54.50 % O by mass. The experimentally determined molecular mass is 176 amu. Determine the empirical and chemical formula for ascorbic acid. (4 marks)

e) Calculate the *de Broglie* wavelength (in nanometers) associated with beam of neutrons moving at a speed of 1.0×10^{10} m/s. (mass of a neutron = 1.67495×10^{-24}g) (2 marks)

f) 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)

QUESTION FIVE (20 MARKS)

a) Draw the Lewis structure of the following compounds:

i. H_2O

ii. NO

iii. $AlCl_3$ (3 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…) to n_1 = (2). Name the other 4 series in the hydrogen atomic spectra and the transitions involved. (4 marks)

c) 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)

d) Sketch the three orbitals for which $l = 1$: (2 marks)

e) Urea, $CO(NH_2)_2$, is manufactured on a large scale for use in producing fertilizer. Calculate the maximum mass of urea that can be manufactured from the CO_2 produced by combustion of 1.00×10^3 kg of carbon followed by the reaction below. (4 marks)

$CO_2(g) + 2NH_3(g) \rightarrow CO(NH_2)_2(s) + H_2O(l)$

f) 25.0 cm^3 of 0.050 mol/dm^3 sodium carbonate was completely neutralised by 20.00 cm^3 of dilute hydrochloric acid. Calculate the concentration in mol/dm^3 of the hydrochloric acid. (4 marks)