CHUKA UNIVERSITY

UNIVERSITY EXAMINATIONS

FIRST YEAR EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE AND BACHELOR OF EDUCATION (SCIENCE)

CHEM 102: GENERAL INORGANIC AND PHYSICAL CHEMISTRY

STREAMS: BSC **TIME: 2 HOURS**

DAY/DATE: FRIDAY 06/12/2019 **11.30 A.M. – 1.30 P.M.**

INSTRUCTIONS:

- **Answer question ONE and any other TWO questions**

QUESTION ONE (30 MARKS)

a) Define the following terms (2 marks)

i. Mass number

ii. Isotopes

b) The isotopes and abundances of silicon are given below. Calculate the average atomic mass of silicon (2 marks)

Si-28	27.977 amu	92.34%
Si-29	28.977 amu	4.70%
Si-30	29.974 amu	2.96%

c) For the tin atom $^{118}_{50}Sn$ determine the following; (2 marks)

i. atomic number

ii. mass number;

iii. number of electrons

iv. number of neutrons

d) Calculate the number of molecules that are contained in a 325-mg tablet of aspirin ($C_9H_8O_4$, molar mass 180.2 g/mol) (2 marks)

e) Calculate the concentration of a solution formed by diluting 25.0 mL of a 3.8 M glucose solution to 275 Ml. (2 marks)

f) Lead is a poisonous metal that especially affects children because they retain a larger fraction of lead than adults do. Lead levels of 0.25 ppm in a child cause delayed cognitive development. Determine the moles of lead present in 1.00 g of a child's blood would 0.25 ppm present (RFM of Pb=207.2 g/mol). (3 marks)

g) Consider the following species: PCl_3; BF_3; CO_2; CO_3^{2-}

i. Write the Lewis structures of each the species (4 marks)

ii. Draw resonance structures for CO_3^{2-} (1 marks)

iii. Determine the molecular geometries of PCl_3, BF_3 and CO_2 (3 marks)

iv. Determine the hybridization of the central atom in PCl_3, BF_3 and CO_2 (3 marks)

h) Calculate, at 25°C, the $[H^+]$ and pH of a tap water sample in which $[OH^-] = 2.0\ 10^{-7}$ (3 marks)

i) Balance the following redox equation

$Fe^{2+} + MnO_4^-$ $Fe^{3+} + Mn^{2+}$ (acidic conditions) (3 marks)

QUESTION TWO (20 MARKS)

a. State the Pauli's exclusion principle (1 mark)

b. Write the ground state electronic configuration of ;

i. Sulfur atom (S=16)

ii. Fe^{2+} ion (Fe=26) (2 marks)

c. Explain briefly how the following properties of the elements vary across a period and down a group in the periodic table (6 marks)

i. Atomic radius

ii. Ionization energy

iii. Electronegativity

d. The periodic table shows the arrangement of elements according to the atomic numbers.

(3 marks)

i. What do the elements in the same group have in common?

ii. What do elements in the same period have in common?

iii. Explain why metals are generally electropositive while non-metals are electronegative

e. Wine is produced by the fermentation of grapes. In fermentation, the carbohydrate glucose ($C_6H_{12}O_6$) is converted to ethanol and carbon dioxide according to the given balanced equation. Determine the grams of ethanol (C_2H_6O, molar mass 46.1 g/mol) that are produced from 5.00 mol of glucose. (4 marks)

$$\underset{\text{glucose}}{C_6H_{12}O_6(aq)} \longrightarrow 2\,\underset{\text{ethanol}}{C_2H_6O(aq)} + 2\,CO_2(g)$$

f. A student prepares a sample of hydrogen gas by electrolyzing water at 25°C. She collects 152 mL of H_2 at a total pressure of 758 mm Hg. Taking the vapor pressure of water at 25°C to be 23.76 mm Hg, calculate; (4 marks)

i. The partial pressure of hydrogen.

ii. The number of moles of hydrogen collected.

QUESTION THREE (20 MARKS)

a. Carbon monoxide absorbs energy with a frequency of 6.510^{10} s^{-1}.
(3 marks)

i. Calculate the wavelength of the absorption

ii. Find the energy absorbed by one photon

b. Calculate the wavelength in nanometers of a transition in a hydrogen atom from n=2 to n=5 ($R_H = 1.09710^{-2}$ nm^{-1}) (2 marks)

c. Aspirin, a commonly used pain reliever, is a weak organic acid whose molecular formula may be written as $HC_9H_7O_4$ (Mw = 180.15 g/mol). An aqueous solution of aspirin has total volume 350.0 mL and contains 1.26 g of aspirin. The pH of the solution is found to be 2.60. Calculate Ka (the dissociation constant) for aspirin. (4 marks)

d. Hexamethylenediamine (MM = 116.2 g/mol), a compound made up of carbon, hydrogen, and nitrogen atoms, is used in the production of nylon. When 6.315 g of hexamethylenediamine is burned in oxygen, 14.36 g of carbon dioxide and 7.832 g of water are obtained. Determine the simplest and molecular formulas of this compound? (6 marks)

e. Explain how the real gases deviate from the ideal gases in obeying the ideal gas law. (2 marks)

f. Sulfur hexafluoride is a gas used as a long-term tamponade (plug) for a retinal hole to repair detached retinas in the eye. If 2.50 g of this compound is introduced into an evacuated 500.0-mL container at 83°C, calculate the pressure (in atmospheres) that is developed. (3 marks)

QUESTION FOUR (20 MARKS)

a. For the reaction given below, indicate the Brønsted-Lowry acid, base, conjugate acid and conjugate base. (2 marks)

$HNO_{2(aq)} + OH^-_{(aq)} \rightleftharpoons NO_2^-(aq) + H_2O$

b. Solution A has a pH of 12.32. Solution B has $[H^+]$ three times as large as that of solution A. Solution C has a pH half that of solution A.
   i. Calculate the $[H^+]$ for all three solutions. (5 marks)
   ii. Calculate the pH of solutions B and C. (2 marks)
   iii. Classify each solution as acidic, basic, or neutral. (3 marks)

c. Consider the following reaction.

$H_2(g) + I_2(g) \rightleftharpoons 2\ HI(g)$

i. Write the expression for the equilibrium constant (K). (1 mark)

ii. Calculate K using the following concentrations of each substance at equilibrium: [H2] = 0.95 M;

$[I_2]$ = 0.78 M; [HI] = 0.27 M. (2 marks)

d. Consider the endothermic conversion of oxygen to ozone: $3O_2(g) \rightleftharpoons 2\ O_3(g)$. Briefly explain the effects of each of the following changes on the direction of equilibrium. (2 marks)

(i) Decrease $[O_3]$ (iii) decrease temperature
(ii) Decrease $[O_2]$ (iv) increase pressure

e. The following data were measured for the reduction of nitric oxide with hydrogen

$2NO(g) + 2H_2(g) \quad N_2(g) + 2H_2O(g)$

Initial concentration(mol L^{-1})		Initial rate of formation of H_2O (mol L^{-1})
[NO]	$[H_2]$	
0.10	0.10	1.2310^{-3}
0.10	0.20	$2.46\ 10^{-3}$
0.20	0.10	$4.92\ 10^{-3}$

Calculate the rate law for the reaction. (3 marks)
