
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)
- Mass number
 - 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 $^{118}_{50}\text{Sn}$ determine the following; (2 marks)
- atomic number
 - mass number;
 - number of electrons
 - 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-}
- Write the Lewis structures of each the species (4 marks)
 - Draw resonance structures for CO_3^{2-} (1 marks)
 - Determine the molecular geometries of PCl_3 , BF_3 and CO_2 (3 marks)
 - 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 $[OH^-] = 2.0 \times 10^{-7}$ (3 marks)
- i) Balance the following redox equation
 $Fe^{2+} + MnO_4^- \rightarrow Fe^{3+} + Mn^{2+}$ (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 ;
- Sulfur atom (S=16)

ii. Fe^{2+} ion ($\text{Fe}=26$) (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)

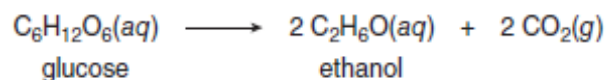
- i. Atomic radius
- ii. Ionization energy
- iii. Electronegativity

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 ($\text{C}_6\text{H}_{12}\text{O}_6$) is converted to ethanol and carbon dioxide according to the given balanced equation. Determine the grams of ethanol ($\text{C}_2\text{H}_6\text{O}$, molar mass 46.1 g/mol) that are produced from 5.00 mol of glucose. (4 marks)



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)

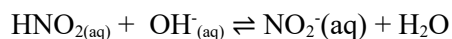
a. Carbon monoxide absorbs energy with a frequency of $6.510^{10} \text{ s}^{-1}$. (3 marks)

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- 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 $n=5$ ($R_H = 1.09710^{-2} \text{ nm}^{-1}$) (2 marks)
- c. Aspirin, a commonly used pain reliever, is a weak organic acid whose molecular formula may be written as $\text{HC}_9\text{H}_7\text{O}_4$ ($M_w = 180.15 \text{ g/mol}$). 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 K_a (the dissociation constant) for aspirin. (4 marks)
- d. Hexamethylenediamine ($M_w = 116.2 \text{ g/mol}$), 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)

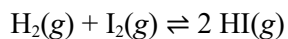
QUESTION FOUR (20 MARKS)

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



- b. Solution A has a pH of 12.32. Solution B has $[\text{H}^+]$ three times as large as that of solution A. Solution C has a pH half that of solution A.
- i. Calculate the $[\text{H}^+]$ 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.



- i. Write the expression for the equilibrium constant (K). (1 mark)
- ii. Calculate K using the following concentrations of each substance at equilibrium: $[\text{H}_2] = 0.95 \text{ M}$;
 $[\text{I}_2] = 0.78 \text{ M}$; $[\text{HI}] = 0.27 \text{ M}$. (2 marks)

d. Consider the endothermic conversion of oxygen to ozone: $3\text{O}_2(\text{g}) \rightleftharpoons 2 \text{O}_3(\text{g})$. Briefly explain the

effects of each of the following changes on the direction of equilibrium. (2 marks)

- (i) Decrease $[\text{O}_3]$ (iii) decrease temperature
- (ii) Decrease $[\text{O}_2]$ (iv) increase pressure

e. The following data were measured for the reduction of nitric oxide with hydrogen
 $2\text{NO}(\text{g}) + 2\text{H}_2(\text{g}) \rightleftharpoons \text{N}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$

Initial concentration(mol L ⁻¹)		Initial rate of formation of H ₂ O (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)
