Technical University of Mombasa

Faculty of Applied and Health Sciences

DEPARTMENT OF ENVIRONMENT AND HEALTH SCIENCES

UNIVERSITY EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN MARINE RESOURCE MANAGEMENT

BMRM
ACH 4102 : FUNDAMENTALS OF CHEMISTRY

SEMESTER EXAMINATION

DECEMBER 2013 SERIES 2 HOURS

Instructions to candidates:

This paper consist of **FIVE** questions
Answer question **ONE** (compulsory) and any other **TWO** questions

QUESTION ONE

a) Specify the set of quantum numbers used to describe an atomic orbital and state the possible values of each. **(3marks)**

b) Describe the characteristics of a $dx^2 - y^2$ orbital **(3marks)**

c) 36ml of a HNO_3 solution is required to neutralize 25ml of a 0.53M Ba $(OH)_2$ solution. Calculate the concentration of the acid solution. (H = 1, N = 14, 0 = 16, Ba = 137) **(4marks)**

d) Write the equilibrium constant expression and calculate its numerical value for the basic dissociation of NaH_2PO_4, given Ka1 value for H_3PO_4 is 7.5×10^{-3}. **(4marks)**

e) Explain the hydrolysis of salts that produce acidic solutions, with an appropriate example. **(4marks)**

f) Write the solubility equilibrium equations and solubility product expressions for the

following compounds

(i) $Ca_3(PO_4)_2$
(ii) $PbCrO_4$
(iii) $Fe(OH)_3$

(3marks)

g) Indicate the oxidation number of the underlined atom in each of the following species

(i) $\underline{S}_2O_3^{2-}$
(ii) $K_2\underline{Cr}O_4$

(2marks)

h) Describe the characteristics of amphoteric oxides with an appropriate example **(3marks)**
i) Explain the differences in bonding character of NaBr and SO_3 **(4marks)**

QUESTION TWO

a) Draw the Lewis structures for the following species,

(i) SO_3
(ii) $AlCl_3$

(4marks)

b) State any TWO failures of Bohr's theory of the hydrogen atom. **(2marks)**

c) Define the following

(i) Pauli's exclusion principle **(1mark)**
(ii) Hund's rule **(1mark)**
(iii) The Aufbau principle **(1mark)**

d) Write the ground state electron configuration of the following

(i) Mn^{4+} ($\not{Z}$ = 24)
(ii) Ge ($\not{Z}$ = 32)

(2marks)

e) Explain the observation that the radii of isolectronic cations decrease with increase in oxidation number **(2marks)**

f) For the ionic equation

$CN^-(aq) + MnO_4^-(aq) \rightarrow CNO^-(aq) + MnO_2(s)$

(i) Write the unbalanced oxidation and reduction half reactions **(1mark)**

(ii) Write the balanced oxidation and reduction half reactions in basic medium, showing all the steps involved in balancing **(4marks)**

(iii) Write the overall balanced reaction. **(2marks)**

QUESTION THREE

a) Define the following

(i) Electron affinity **(1mark)**

(ii) Electronegativity **(1mark)**

b) Explain why the electron affinities of Mg($\not{Z}$ = 12) and Ar($\not{Z}$ =18) are less than zero **(4marks)**

c) Electronegativity generally decreases from top to bottom in a group of the periodic table. Explain this observation **(2marks)**

d) Explain the variation in the metallic characteristics of C, Si, Ge, Sn and Pb (4marks)

e) (i) Explain the differences in the ionization energies of Be ($\not{Z}$ = 4) and B ($\not{Z}$ = 5) **(4marks)**

(ii) The 1st ionization energies of Na ($\not{Z}$ = 11) and Mg ($\not{Z}$ = 12) are 495.9 and 738.1 $KJmol^{-1}$, respectively. However, the 2nd ionization energies of the same elements are 4,560 and 1,450 $KJmol^{-1}$. Explain this observation **(4marks)**

QUESTION FOUR

a) State L'e chatelier's principle **(2marks)**

b) Explain how the common ion affects the solubility of $CaCO_3$ in a K_2CO_3 solution. **(4marks)**

c) Dilute NaOH is introduced into a solution that is 0.03M in Cu^{2+} and 0.02M in Mn^{2+}.

(i) Which hydroxide precipitates first? **(1mark)**

(ii) Calculate the concentration of OH^- required to initiate precipitation of the second hydroxide. **(4marks)**

(iii) Determine the concentration of the cation forming the less soluble hydroxide when the more soluble hydroxide begins to precipitate? **(3marks)**

(K_{SP} for $Cu(OH)_2 = 2.2 \times 10^{-20}$, and $Mn(OH)_2 = 2 \times 10^{-13}$)

d) Outline the natural processes associated with nitrification **(4marks)**

e) CO burns in air, but CO_2 does not burn. Explain this observation **(2marks)**

QUESTION FIVE

a) Define buffer capacity **(2marks)**

b) A buffer solution was prepared by mixing 500ml of 0.100m NH_3 solution and 500ml of 0.200m NH_4Cl solution. If $Ka = 5.70 \times 10^{-10}$:

(i) Write the equilibrium equation for the acidic dissociation of NH_4Cl **(1mark)**

(ii) Write down the equilibrium equation for the basic dissociation of NH_3 **(1mark)**

(iii) Calculate Kb. **(2marks)**

(iv) Calculate the H^+ ion concentration of the solution **(3marks)**

(v) Calculate the pH of the solution **(1mark)**

c) Explain the nature and how a cation exchange resin functions **(3marks)**

d) Define the following terms as applied to electrochemical cells.

(i) Standard oxidation potential **(1mark)**

(ii) Standard reduction potential **(1mark)**

e) An electrochemical (galvanic) cell consists of a Ag electrode in contact with 1M $AgNO_3$ solution a Mg electrode in Tm Mg $(NO_3)_2$ solution.

(i) Identify the anode and cathode electrodes **(1mark)**

(ii) Write half cell reactions of the respective electrodes **(2marks)**

(iii) Calculate the cell electromotive force ε. **(2marks)**

(ε° $Ag^+/Ag = +0.8V$, ε° $Mg^{2+}/Mg = -2.37V$)