MACHAKOS UNIVERSITY

University Examinations 2021/2022

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR SUPPLEMENTARY/SPECIAL EXAMINATION FOR DIPLOMA IN ELECTRICAL ENGINEERING.

SCU 102: CHEMISTRY

DATE: 15/3/2022 **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** (each 20 marks).

Required data and constants:

1. Atomic numbers Na = 11, Mn= 25, Cu = 29, Ti =22, O = 8 Ba = 56, H = 1, Al = 13, C = 6, Mg = 12, Cl = 17.
2. Ka acetic acid = 1.8×10^{-5} M
3. Ka for Oxalic acid = 3.78×10^{-6}M
4. Ka for nitrous acid =5.0×10^{-4} M

SECTION A

I. (a) Differentiate between an atom and a molecule. (2 marks)

(b) Explain why the atomic mass of an element is a decimal number on the periodic table. (1 mark)

(c) Write the electron configurations of the following species: Na^{+}, Mn^{2+}, Cu^{+}, Ti and O^{2-} (5 marks)

(d) Distinguish the following terms:

i) Ionisation energy and electron affinity (2 marks)

ii) Electronegativity and effective nuclear charge (2 marks)

(e) Write the lewis structures of the following ionic and covalent compounds

i) Aluminium oxide (2 marks)

ii) Nitrogen (2 marks)

iii) Water (1 mark)

(f) By giving relevant examples, differentiate between a bronsted-lowry definition of an acid and a base. (2 marks)

(g) What is a lewis acid? (1 mark)

(h) Calculate the pH of the following acidic solutions:

i) 10^{-3} mol dm^{-3} hydrochoric acid (2 marks)

ii) 0.1 M nitrous acid (HNO_2) (2 marks)

(i) What is meant by the term oxidation number? (1 mark)

(j) Given the following redox reaction. State and explain the substance that acts as an oxidizing agent (2 marks)

$Fe^{3+} + V^{2+} \rightarrow Fe^{2+} + V^{3+}$

(k) Given the following standard reduction potentials,

$Zn^{2+}aq + 2e \rightarrow Zn$ -0.763 V

$Pb^{2+}aq + 2e \rightarrow Pb$ -0.126 V

i) Write the ionic equation for the cell made by combining the two half cells (1 mark)

ii) Calculate the EMF of the cell involving zinc and lead above. (1 mark)

iii) Write the cell notation for the cell (1 mark)

SECTION B: ANSWER ANY OTHER TWO QUESTIONS

2 a) Two Elements X and Y (not their actual symbols) have atomic number 12 and 78 respectively. To which period and groups do they belong? Show your working. (2 marks)

b) Explain the following observations:

i) the first ionization energy of phosphorous is higher than that of oxygen (2 marks)

ii) the first ionization energy of magnesium is higher than that of aluminium (2 marks)

iii) the third ionization energy of Mg exceptionally higher than the second ionization energy (2 marks)

iv) atomic radii decrease across a period but increases down a group (2 marks)

v) the ionic radius of Na^{+} ($2S^2 2P^6$) is greater than that of Mg^{2+} ($2S^2 2P^6$) (2 marks)

c) i) What are hybrid orbitals? (2 marks)

ii) Explain how $2sp^2$ hybridization takes place during formation of boron trifluoride using suitable atomic orbitals (3 marks)

d) i) What are valence electrons? (1 mark)

ii) Write down the valence electron configurations for oxygen and Aluminium (2 marks)

3. a) Write the lewis structures for the following compounds: magnesium oxide, methane, carbon(iv)oxide, magnesium chloride. (4 marks)

b) Using ammonia and boron trifluoride molecules as examples, explain how a coordinate bond is formed. (3 marks)

c) Explain why transition metals have a great tendancy of forming coordinate bonds

(2 marks)

d) Using two water molecules as examples, explain how hydrogen bonds are formed (2 marks)

e) In terms of structure and bonding, explain the following observations:

i) polar organic molecules are generally soluble in water. (2 marks)

ii) The boiling point of methanol is greater than that of butane yet the relative atomic mass of butane is greater than that of methanol. (2 marks)

f) Explain the nature of covalent bond between nitrogen atom (electronegativity 3.0) and oxygen atom (electronegativity 3.5) (2 marks)

g) A tripple covalent bond involves three electron pairs. State and explain how two types of covalent bonds are formed by the electron pairs. (3 marks)

4. a) Explain what is meant by strength of an acid? (2 marks)

b) What is pH? (2 marks)

c) What is the the pH of an aqueous solution with $[OH^-] = 6.3\times10^{-1}$M. (2 marks)

d) What is the $[H_3O^+]$ of an aqueous solution with a pH of 11.8? (3 marks)

e) What is a buffer solution? (2 marks)

f) What is the pH of a buffer solution made from 0.1M acetic acid and 0.1 M sodium acetate solution? (3 marks)

g) i) Write down the overall dissociation equation for oxalic acid. (1 mark)

ii) What volume of of 0.400 M sodium hydroxide is required to neutralize completely a 5.00×10^{-3} mole sample of pure oxalic acid. (2 marks)

iv) Give the equations representing the first and the second dissociations of oxalic acid. Calculate the value of the first dissociation constant K_1, if the value of the second dissociation constant K_2 is $6.40\times10^{-5.}$ (3 marks)

5. a) What are standard electrode potentials? (1 mark)

b) Draw a well labelled diagram that can be used to determine the standard reduction potential for Zinc metal (3 marks)

c) Determine the oxidation number of manganese in the following species:

Mn_2O_3, MnO_2, MnO_4^-, MnO_3 (4 marks)

d) Explain the following observations:

i) When aqueous copper(ii)sulphate was electrolyzed using weighed copper electrodes, for some time, both electrodes were found to have changed in mass. Write the half reactions at both anode and cathode. (3 marks)

ii) In electrolysis of acidified water with platinum electrodes, the volume of hydrogen collected was twice the volume of oxygen collected. (2 marks)

e) State and explain three applications of electrolysis (3 marks)

f) A cell s represented by the following arrangement

Zn(s) /ZnSO4(aq)// CuSO4(aq)/Cu(s). The standard reduction electrode potentials

For zinc and copper are -0.76V and +0.34V respectively.

i) State and explain the electrode which acts as the cathode (2 marks)

ii) Write an equation for the overall cell reaction that occurs when zinc and copper electrodes are connected by a conductor. (1 mark)

iii) Determine the initial e.m.f of the cell in (ii) above. (1 mark)