MACHAKOS UNIVERSITY

University Examinations 2021/2022

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

SECOND YEAR SUPPLEMENTARY/SPECIAL EXAMINATION FOR

BACHELOR OF SCIENCE IN ANALYTICAL CHEMISTRY

SAN 205: AQUATIC CHEMISTRY

DATE: 18/03/2022 **TIME: 8:30-10:30 AM**

INSTRUCTIONS

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks).

SECTION A

Question one Compulsory (30 marks)

(a) Acid- base reactions are examples of equibrium reactions occuring in the aqueous medium.

(i). Derive with the help of chemical equations the water autoionization constant, K_w where water behaves both as an acid and base. (4 marks)

(ii). Derive the base ionization constant K_b and the acid ionization constant K_a. (4 marks)

(iii). From the equations in (i) and (ii) above show that $K_w = K_aK_b$. (3 marks)

(b). Given at 25^0C the Kw for water is $1x10^{-14}$.

(i). Determine the concentrations of OH^- and H^+ ions at 25^0C. (3 marks)

(ii). Explain the statement that the acidity of water depends on temperature. (3 marks)

(iii). Calculate the pH of 10 M HCl, considering HCl is a strong acid, with $K_a = 10^7$. (5 marks)

(iv). What is the value of pOH of the 10 M HCl? (3 marks)

(c). Acetic acid (CH_3CH_2COOH) is a weak acid with Ka = $1.76x10^{-5}$. Determine the pH of 1.712 M solution of acetic acid. (5 marks)

SECTION B

QUESTION TWO (20 MARKS)

(a). Sodium zeolite is a naturally occuring compound used in the removal of water hardness.

(i). Give the chemical structure of sodium zeolite. (2 marks)

(ii). With the help of chemical equations, explain how sodium zeolite is used in removal of both types of hardness. (4 marks)

(iii). Describe how the zeolite is regenerated after use for water softening. (2 marks)

(b). The ion exchangers are either cationic or anionic exchangers.

(i). Describe the chemical structure of the cation exchnager, indicating the main skeleton and the cation exchanger itself. (3 marks)

(ii). Describe the chemical structure of anion exchanger, indicating the main skeleton and the anion exchanger itself. (3 marks)

(iii). Show with the help of chemical equations how the ion exchanger generates deionized water which is free of both cations and anions. (4 marks)

(iv) . Explain how the ion exchangers are regenerated after demineralization. (2 marks)

QUESTION THREE (20 MARKS)

(a) Two methods, Reverse osmosis and Electrodialysis are used in the desalination of sea water to generate water potable water free from ions.

(i). Describe with the help of a diagram how reverse osmosis is used to generate potable water (4 marks)

(ii). Describe with the help of a suitable diagram the process of electrodialysis in the generation of potable water from sea water. (6 marks)

(b). Describe in sequential manner the six steps involved in the treatment of water for domestic use, clearly indicating in each step the major accomplishment. (10 marks)

QUESTION FOUR (20 MARKS)

(a). Water (H_2O) is a dihydride of oxygen which is in group 16 of the periodic table. The other dihydrides down the group are H_2S, H_2Se and H_2Te. (2 marks)

(i). Explain why water is the most common solvent used among the dihydrides in this group.

(ii). Among the dihydrides of this group, water exhibits anomalous behavior. Explain the anomalous behavior exhibited by water among the other dihydrides in the group. (2 marks)

(b). Unpolluted rain water has a pH of 5.5 to 6.5 but the pH of polluted water is highly acidic.

(i). Explain why the pH of rain water is not neutral with a pH of 7. (2 marks)

(ii). Explain in details the cause of acidity in polluted water. (2 marks)

(c). Water which does not produce lather with soap but forms a white precipitate is called hard water.

(i). Explain chemically the two types of water hardness and their causes. (3 marks)

(ii). Explain how both types of water hardness are removed from water. (3 marks)

(iii). Explain how hardness of water is determined by the EDTA method. (3 marks)

(iv). What problems are encountered when using hard water for many different applications? (3 marks)

QUESTION FIVE (20 MARKS)

(a). Systems are required to maintain environments of constant pH.

(i). State the operational (how does it do ?)and technical (what does it do?) definitions of a buffer. 3 marks

(ii). Write equations that show what happens when a small amount of a strong acid (H+) or a strong base (OH-) are added to a buffer? 3 marks

(iii). Explain why the pH does not change very much when a small amount of strong acid or base is added to a buffer? 4 marks

(iv). Explain what is the buffering capacity of a buffer. 3 marks

(b). Derive the Handerson- Hasselbalch (H-H) equation for providing a recipe for making a buffer of a given pH. 7 marks