MACHAKOS UNIVERSITY

University Examinations 2021/2022

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

SECOND YEAR SUPPLEMENTARY/SPECIAL EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN ANALYTICAL CHEMISTRY

SAN 200: SEPARATION AND PURIFCATION TECHNIQUES

DATE: 15/03/2022 **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 (COMPULSORY)

QUESTION ONE (30 MARKS)

(a) Differentiate between the following terms as used in environmental analysis of samples:

i. Precision and accuracy as used in qualitative and quantitative analysis. (2 marks)

ii. Chromatogram and chromatography (2 marks)

iii. Split and splitless modes of sample injection as used in Gas Liquid Chromatographic studies. (2 marks)

iv. Simple extraction and multiple extraction as used in distribution law. (2 marks)

(b) With the aid of clearly labelled diagram, outline the different parts of a High-Performance Liquid Chromatography. (6 marks)

(c) Explain the four main ways of expressing concentration in chemical analysis. (4 marks)

(d) Azariah is a chemical engineer working in a pharmaceutical company laboratory. His daily activities involve extraction of solutes from aqueous solution. Outline how liquid- liquid partition technique can be used to extract benzoic acid as a food preservative. (6 marks)

(e) The solubility of pure oxygen in water at 20^{o} C and 1.00 atm pressure is $1.38* 10^{-3}$ mole/litre. Calculate the concentration of oxygen (mole/litre) at 20^{o} C and a partial pressure of 0.21 atm. (6 marks).

SECTION B (ANSWER ANY TWO QUESTIONS)

QUESTION TWO (20 MARKS)

(a) The analytical process is the science of taking measurements in an analytical and logical way. It involves the two main steps of qualitative and quantitative analysis of sample. Identify and explain the main steps involved in qualitative and quantitative analysis process. (6 marks)

(b) Nernst (1891) studied the distribution of several solutes between different appropriate pairs of solvent. Name and explain the conditions to be satisfied for the application of the Nernst distribution law (5 marks)

(c) Oil refinery companies are good examples of the companies using fractional distillation technique for the purification and separation of crude oil to its individual components. With an aid of a diagram, explain the working of a fractional distillation apparatus as applied in oil refinery companies (6 marks)

(d) Soxhlet extraction is a technique applied in chemistry for analysis of residue levels of contaminants. Briefly explain your understanding of soxhlet technique as applied in chemist (3 marks).

QUESTION THREE (20 MARKS)

(a) The solubility of a gas in a solvent depends on the pressure and the temperature. State the Henrys law. (3 marks)

(b) An aqueous solution contains 10g of solute per litre. When 1 litre of the solution is treated with 100ml of ether, 6g of the solute are extracted. How much more of the solute would be extracted

from the aqueous solution by a further 100 ml ether? Assume that the molecular state of the solute is the same in ether or water. (6 marks)

(c) Differentiate between the terms dissolution and recrystallization (3 marks)

(d) Scientific researchers apply a wide range of analytical techniques in undertaking qualitative and quantitative analysis. Some of the techniques applied include GC, HPLC and TLC. With an aid of a diagram, name and explain the functions of the four main components of a thin layer chromatography. (8 marks)

QUESTION FOUR (20 MARKS)

(a) Research has demonstrated that it is advantageous to use a given quantity of the solvent in as many portions as conveniently possible. It must be understood, however, that it is not possible to remove the whole of the dissolved substance, however large the number of extractions may be. Derive the general formula for calculating the substance left unextracted in an analytical experiment. (8 marks)

(b) With an aid of a diagram, explain how the pH of an environmental sample can be determined in the laboratory. (4 marks)

(c) A solution of 6 g of substances X in 50 ml of aqueous solution is in equilibrium, at room temperature, with a solution of X in ether containing108 g of X in 100 ml. calculate the mass of X extracted by shaking 100 ml of an aqueous solution containing 10 g of X with (a) 100 ml of ether; (b) 50 ml of ether twice at room temperature. (8 marks)

QUESTION FIVE (20 MARKS)

(a) Using examples differentiate between saturated and unsaturated solution. (3 marks)

(b) Using a diagram explain the theory steam distillation as a technique used for purification of organic liquids which are steam volatile and immiscible with water. (8 marks)

(c) State the law of mass action and provide the equilibrium constant expression for the reaction shown below. (3 marks)

$$N_2O_{5(g)} \text{.....} NO_{2(g)} + O_{2(g)}.$$

(d) 5 g of sodium chloride is dissolved in 1000 g of water. If the density of the resulting solution is 0.997 g/mL, calculate the molality, molarity, normality and mole fraction of the solute, assuming the volume of the solution is equal to that of the solvent. (6 marks)