MANICALAND STATE UNIVERSITY OF APPLIED SCIENCES

FACULTY OF ENGINEERING, SCIENCE AND TECHNOLOGY

DEPARTMENT: CHEMICAL AND PROCESSING ENGINEERING

MODULE: ANALYTICAL CHEMISTRY

CODE: CHEP 226

SESSIONAL EXAMINATIONS
APRIL 2023

DURATION: 3 HOURS

EXAMINER: MR M. MAPOSA

INSTRUCTIONS

1. *Answer **Any four** questions*
2. *All questions carry the same number of marks*
3. *Start a new question on a fresh page*
4. *Total marks 100*

Additional material(s): *Periodic Table*
Graph page

QUESTION 1

a) Describe fully the following terms

i) Solvent extraction

ii) Partition co efficient [4]

b) State any two properties of a good solvent for solvent extraction [2]

c) Discuss two risks associated with the use of solvent extraction [4]

d) Two samples from the same crude industrial effluent were known each to contain 3 g of a phenol per 100 ml of aqueous solution. During phenol recovery experiments, the samples were treated with ether in two different ways to extract the phenol;

Sample 1: 100 ml of ether once

Sample 2; 50 ml of ether twice at room temperature. Given that the partition coefficient is 40,

i) Calculate the mass of phenol extracted in each case

ii) Calculate the percentage recovery in each case

iii) At 30 ^{o}C 100 ml of ether extracted 2.95 g of the phenol. Determine the partition coefficient at 30 ^{o}C [15]

QUESTION 2

a) Distinguish between

i) Permanent and temporary hardness of water

ii) Soft and hard water

iii) Chelating ligands and non-chelating ligands [6]

b) A calcium supplement tablet which is known to contain 300 mg Ca was dissolved in water, filtered and diluted to 100 mL volume. Upon titration with 0.0100 M EDTA 2.00 mL sample of the solution required 13.65 mL (0.01365 L) of EDTA solution for a complete reaction. Calculate

i) the calcium concentration of the prepared solution in mol dm^{-3}

ii) pCa for the solution

iii) the calcium content of the supplement tablet to the nearest **mg** unit.

iv) the percentage efficiency of this analysis [10]

c) A mixture of ammonia and ammonium nitrate constitutes a buffer solution

i) Explain how a mixture of ammonia and ammonium nitrate can act as a buffer

ii) Calculate the pH of the resulting solution when 0.2 mols ammonia and 0.25 mol ammonium nitrate are mixed in 2 dm^3 solution given that the K_b value of ammonia is 1.75×10^{-5} $moldm^{-3}$

iii) Calculate the pH change when 10 cm^3 of 0.1 $moldm^{-3}$ Hydrochloric acid is added to the mixture in c) ii) above. [9]

QUESTION 3

a) Describe the principle behind each of the four types of gravimetric analysis [8]

b) Give any two limitations and two strengths of gravimetric analysis [4]

c) A 1 g sample was composed of 75 % potassium sulphate (Mr 174.25) and 25 % MSO_4 and both are soluble in water. The sample was dissolved and excess barium nitrate was added to precipitate all the sulphate ions as barium sulphate, ($BaSO_4$) (Mr 233.39). If the $BaSO_4$ ppt produced weighed 1.49 g, what is the atomic mass and the identity of M^{2+} in MSO_4? [5]

d) Quantitative analysis of chloride ions in aqueous solutions can be done through the Volhard method. Describe the procedure fully, highlighting the reagents used, measurements you required and the calculations you would need to carry out. [5]

e) A 25 ml sample of an industrial effluent was titrated directly against 0.01moldm^{-3} silver nitrate solution in the presence of potassium chromate indicator. It was found that 20 ml of silver nitrate solution was enough to precipitate all the chloride ions and reach end point. Calculate the chloride ion concentration in the effluent in ppm. [3]

QUESTION 4

a) Explain the need for the following practices during an analysis

i) Taking repeated readings

ii) Calibrating the instruments

iii) validating methods of analysis [9]

b) Distinguish between internal standards and external standards in instrumental analysis [4]

c) The following set of data was obtained during the calibration of a UV-VIS instrument before measuring tartrazine concentration in a beverage.

Concentration	Absorbance
0	0
0.0001	0.51
0.0005	2.41
0.0010	4.92
0.0015	7.40

i) State the qualities of a good calibration curve

ii) Plot a calibration curve using the data in the table

iii) Deduce the equation of relationship between concentration and absorbance

iv) Use your graph to determine the tartrazine concentration in a sample which gave an absorbance reading of 2.45 [12]

QUESTION 5

a) Nernst equation is an important tool in potentiometry

i) State the Nernst equation for the determination of cell potential

ii) Suggest the significance of Nernst equation in electrochemistry

iii) A zinc-lead cell has an overall equation: $Zn_{(s)} + Pb^{2+}_{(aq)} \rightarrow Zn^{2+}_{(aq)} + Pb_{(s)}$

Calculate the standard cell potential of the system

iv) Calculate the cell potential when 0.1 $moldm^{-3}$ Zn^{2+} and 0,15 $moldm^{-3}$ Pb^{2+} are the electrolytes at 30 ^0C [8]

b) Explain how cell potential is affected by

i) Temperature of the electrolyte

ii) Concentration of ions in the electrolytes

iii) Positions of electrode material on the electrochemical series [6]

c) An excess of a metal sulphate represented as MSO_4 was dissolved in water at 21 ^oC and only 1.29×10^{-11} $moldm^{-3}$ SO_4^- was present in the saturated solution. Find

i) the solubility and the solubility product, Ksp of the metal sulphate

ii) the solubility of the metal sulphate in 1M Na_2SO_4 solution [5]

d) Describe the strengths and limitations of the following spectroscopic methods

i) Raman spectroscopy

ii) UV-VIS spectroscopy [6]

END OF EXAMINATION