MAASAI MARA UNIVERSITY

REGULAR UNIVERSITY EXAMINATIONS
2022/2023 ACADEMIC YEAR
FIRST YEAR SECOND SEMESTER

SCHOOL OF PURE APPLIED AND HEALTH SCIENCES
BACHELOR OF SCIENCE IN CHEMISTRY

COURSE CODE: CHE 1208-1
COURSE TITLE: ANALYTICAL CHEMISTRY I

DATE: 18TH APRIL, 2023   **TIME: 2:30 – 4:30 PM**

INSTRUCTIONS TO CANDIDATES

1. Answer Question **ONE** and any other **TWO** questions in section **B**
2. No writing on the Question paper
3. Use of mobile phone in the exam room is prohibited

RAM values

Ag = 108, Br = 80, Rb = 85, N = 14, Fe = 55.8, S= 32.0 and O = 16

QUESTION ONE [30 MARKS]

a) Define the following terms as used in analytical chemistry;

   i.   Titrimetric analysis [1 mark]
  ii.   Molality [1 mark]
 iii.   Dimensional analysis [1 mark]
 iv.   Common ion effect [1 mark]
  v.   Blank [1 mark]

b) Why is it important to elucidate the limiting reagent of a reaction? [3 marks]

c) A reaction container holds 6.8 g of P_4 and 6.8 g of O_2. The following reaction occurs:

$P_4 + O_2 \longrightarrow P_4O_6$. If enough oxygen is available then the P_4O_6 reacts further:

$P_4O_6 + O_2 \longrightarrow P_4O_{10}$. (P=31, O =16)

a. What is the limiting reagent for the formation of P_4O_{10}? [1 mark]

b. What mass of P_4O_{10} is produced? [2 marks]

d) Commercial HNO_3 acid is $68\%^w/_w$ and it has a specific gravity of 1.39g/ml. Find the formal concentration of this acid. [3 marks]

e) The diameter of a silver atom is 43Å. Assuming the atom has a spherical shape, find its volume and express your answer in SI units. [3 marks]

f) Will a precipitate of $CaSO_4$ form in a solution if the Ca^{2+} concentration is 0.0025 M and the SO_4^- concentration is 0.030 M? For $CaSO_4$, $K_{sp} = 2.4 \times 10^{-5}$. [3 marks]

g) A solution of acetic acid, CH_3COOH is made by dissolving 13g of the powder in 150ml distilled water. The mixture has a density of 1.8 g/ml. Use the above information to calculate its concentration in;

     i.   mol/litre [1 mark]
    ii.   grams/litre [1 mark]
   iii.   molality [1 mark]
   iv.   normality [1 mark]
    v.   concentration by percent [1 mark]

h) State two application of the common ion effect [2 marks]

i) 1.5g of solid silver bromide was reacted with 12.5 M rubidium nitrate solution. Calculate the volume of solution used [3 marks]

QUESTION TWO [10 MARKS]

a) What do you understand by the term;

   i) gravimetric analysis [1 mark]

   ii) wet chemistry analysis [1 mark]

b) A rock sample is to be assayed for its tin content by an oxidation-reduction titration with I_3^-(aq). A 10.00 g sample of the rock is crushed, dissolved in sulfuric acid, and passed over a reducing agent so that all the tin is in the form Sn^{2+}. The Sn^{2+}(aq) is completely oxidized by 34.60 mL of a 0.5560 M solution of NaI_3. The balanced equation for the reaction is

   I_3^-(aq) + Sn^{2+}(aq) ---> Sn^{4+}(aq) + $3I^-$(aq)

   i) Calculate the amount of tin in the sample and its mass percentage in the rock

   [6 marks]

   ii) State two possible sources of error in this analysis [2 marks]

QUESTION THREE [10 MARKS]

   a) Differentiate between random and systemic errors [1 mark]

   b) Describe the following methods used to correct errors;

   i. Validation [1 mark]

   ii. Calibration [1 mark]

   iii. Standardization [1 mark]

c) State any two methods used to correct human errors [1 mark]

d) Calculate the solubility product constant for SrF_2 given the molar concentration of the saturated solution is 5.6×10^{-4}M [2 marks]

e) During an analysis, 1.7011 g of an impure rock sample suspected to contain silver was reacted with an acid. The mixture was precipitated out and 0.9805 g of AgCl was obtained. What is the percentage by mass of silver in the sample? [3 marks]

QUESTION FOUR [10 MARKS]

a) Define the following terms as used in titrimetry;

   i.   Titrand   **[1 mark]**

   ii.   Titrant   **[1 mark]**

   iii.   Analyte   **[1 mark]**

b) Lawnsand contains 40% $FeSO_4.(NH_4)_2SO_4.6H_2O$ (Mohr's salt). 3.5g of lawnsand was dissolved using 40ml distilled water and transferred to a 100ml volumetric flask then filled to the mark. 25ml of the solution was then transferred into a clean elrnemeyer flask. An unknown amount of potassium permanganate was standardized using this solution. The average titre was found to be 10.00ml.

i) What is a standard solution? **[1 mark]**

ii) How many grams of Mohr's salt (Ferrous ammonium sulphate) are in the lawn sand? **[1 mark]**

iii) Find the number of moles in the 100ml volumetric flask and conical flask

[2 marks]

iv) The standardization reaction proceeds as shown in the reaction below;

$$5Fe^{2+} + 8H^+ + MnO_4 \longrightarrow 5Fe^{3+} + 4H_2O + Mn^{2+}$$

Find the concentration of potassium permanganate solution. **[3 marks]**

QUESTION FIVE [10 MARKS]

   a) The amount of $Fe^{2+}(aq)$ in an $FeSO_4(aq)$ solution can be determined by titration with a solution containing a known concentration of $Ce^{4+}(aq)$. The determination is based on the reaction: $Fe^{2+}(aq) + Ce^{4+}(aq) \text{---}> Fe^{3+}(aq) + Ce^{3+}(aq)$

      Given that it requires 37.50 mL of 0.09650 M $Ce^{4+}(aq)$ to oxidize the $Fe^{2+}(aq)$ in a 35.00 mL sample to $Fe^{3+}(aq)$, calculate the molarity of $Fe^{2+}(aq)$ and the number of milligrams of iron in the sample. **[5 marks]**

   b) The molar solubility of $PbBr_2$ is 2.17 x 10^{-3} M at a certain temperature. Calculate K_{sp} for $PbBr_2$. **[3 marks]**

   c) What is the normality of a 0.5 M lead chloride solution? **[2 marks]**