

P525/2
CHEMISTRY
THEORY
Paper 1
25 July 2022
2 ½ hours

ENTEBBE JOINT EXAMINATION BUREAU

Uganda Advanced Certificate of Education

CHEMISTRY

Paper 2

2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES:

Attempt any five questions including three questions from Section A and any two questions from Section B.

Mathematical tables and graph papers are provided.

Non – programmable scientific calculators may be used

Where necessary, use the following values:

[C = 12, O = 16, H = 1]

Begin each question on a fresh page.

EXAMINERS' USE ONLY						Total mark
QUESTION						
SCORE						

SECTION A

Answer **three** questions from this Section

1. An organic compound **T** contains 60.00 % carbon, 13.3% hydrogen, and the rest being oxygen. When 0.23 g of **T** was vaporized at 29⁰C and 90.2 mmHg, it occupied a volume of 800 cm³.
- (a) Determine the:
- (i) empirical formula of **T**. (02 marks)
 - (ii) molecular formula of **T**. (03 marks)
($R = 8.31 JK^{-1} mol^{-1}$)
- (b) **T** reacts with phosphorous pentachloride at room temperature to produce white fumes.
- (i) Name the functional group in **T**. (01 mark)
 - (ii) Write the structural formulae and IUPAC names of all possible isomers of **T**. (02 marks)
- (c) **T** reacts with a solution of concentrated hydrochloric acid and anhydrous zinc chloride to form a cloudy solution after 8 minutes.
- (i) Identify **T**. (½ mark)
 - (ii) Explain why a cloudy solution is formed. (1½ mark)
 - (iii) Write a mechanism for the reaction between **T** and concentrated hydrochloric acid. (02 marks)
- (d) Describe how **T** can be
- (i) prepared from 2, 2-dibromopropane. (04 marks)
 - (ii) converted to butanoic acid. (04 marks)
(Equation(s) are not required)

2. (a) State **Kohlrausch's law of independent migration of ions**.
(01 mark)
- (b) At 298K, a solution containing 2.84 g per litre of anhydrous sodium sulphate has an electrolytic conductivity of $5.196 \times 10^{-3} \Omega^{-1}\text{cm}^{-1}$. Determine the:
- (i) molar conductivity of sodium sulphate solution. (03 marks)
- (ii) molar conductivity of sodium ions in the solution.
(The molar conductivity of sulphate ions is $159.6 \Omega^{-1}\text{cm}^2\text{mol}^{-1}$ at 298K)
(02 marks)
- (c) (i) Draw a sketch graph to show how molar conductivity of sodium sulphate varies with the square root of concentration.
- (ii) Explain the shape of the graph you have sketched in (c)(i) above.
(03 marks)
- (d) The table below shows the molar conductivity of bromoethanoic acid at different concentrations.

Concentration (mol dm^{-3})	0	0.004	0.02	0.20
Molar conductivity $\Omega^{-1}\text{cm}^2\text{mol}^{-1}$	411	55	18	7

- (i) Explain the trend in the molar conductivity of bromoethanoic acid.
(02 marks)
- (ii) Calculate the degree of ionization of bromoethanoic acid at the dilution of $50 \text{ mol}^{-1}\text{dm}^3$.
(2½ marks)
- (iii) Determine the pH and hence the ionization constant, K_a of the acid in (d)(ii) above.
(4½ marks)

3. Fluorine, chlorine, bromine and iodine are elements of group (VII) of the periodic table.

- (a) Write the formulae of the hydrides of the elements. (02 marks)

- (b) The table below shows the boiling points of the hydrides of the above elements.

Hydrides:	<i>F</i>	<i>Cl</i>	<i>Br</i>	<i>I</i>
Boiling point ($^{\circ}\text{C}$)	+19.9	-85.0	-66.7	-35.4

- (i) Explain the trend of boiling points of the hydrides of the above elements.
(04 marks)

- (ii) State **two** other properties in which the hydride of fluorine differs from hydrides of other group (VII) elements.

(02 marks)

- (c) Describe the reaction of the hydrides of the above elements with:

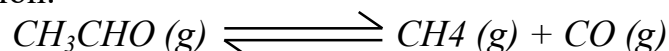
(i) Concentrated sulphuric acid. (5½ marks)

(ii) Potassium carbonate (2½ marks)

- (d) Describe the preparation of chlorine on a large scale. (Diagram not required) (04 marks)

4. (a) State what is meant by the terms **activation energy** and **order of reaction**. (02 marks)

- (b) Ethanol decomposes when heated according to the following equation:



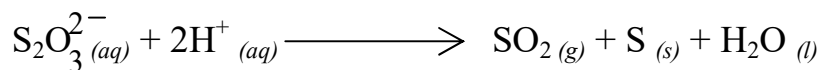
Calculate the enthalpy of decomposition of ethanol. (The standard enthalpies of combustion of ethanal, methane and carbon monoxide are -1187, -884 and -283.5 KJmol⁻¹ respectively.) (03 marks)

- (c) The energy of activation for the catalysed and uncatalysed decomposition of ethanol are 136 and 190 KJmol⁻¹ respectively.

(i) Draw the reaction profiles using the same axes for the catalysed and uncatalysed reactions. Indicate the values of activation energy and heat change. (04 marks)

(ii) Explain how a catalyst increases the rate of decomposition of ethanol. (02 marks)

- (d) The rate equation for the reaction

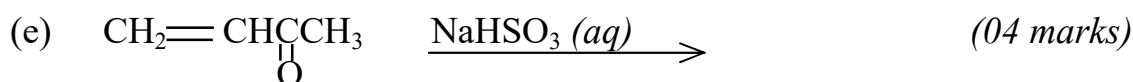
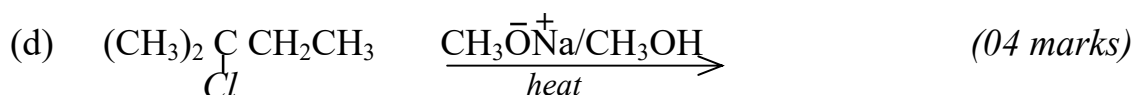
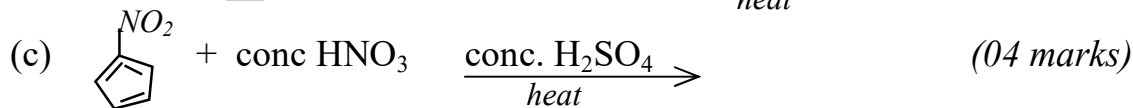
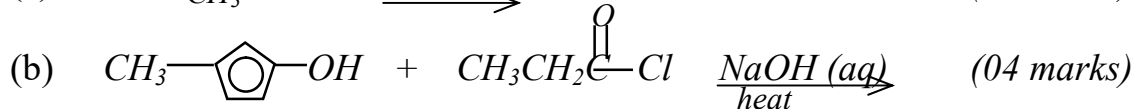


is given by; Rate = K [S₂O₃²⁻] [H⁺]²

(i) Deduce how the rate will be affected when the concentrations of the reactants are all tripled. (02 marks)

(ii) Describe an experiment to determine the order of the reaction with respect to thiosulphate ions in the laboratory. (07 marks)

5. Complete the following equations and outline the possible mechanism for the reaction in each case.



6. The atomic numbers of calcium and chromium are 20 and 24 respectively.

(a) Write the electronic configuration of the atom of each element. (02 marks)

(b) (i) State **three** properties in which chromium differs from calcium. (1½ marks)

(ii) Explain why chromium has a high melting point than calcium. (02 marks)

(c) Describe the reaction of chromium with:

(i) Water (2½ marks)

(ii) Sulphuric acid (04 marks)

(d) Explain the reactions that take place when chromium(III) sulphate solution is treated with:

(i) excess concentrated ammonia solution. (04 marks)

(ii) potassium sulphite solution (04 marks)

7. Steam distillation is one of the methods used in purification of substances below their boiling points.

(a) (i) State **three** requirements for purifying a substance by steam distillation. (1½ marks)

(ii) Explain the principle of purifying a substance by steam distillation method. (03 marks)

- (b) Cyclohexane distils on steam at 98°C and standard atmospheric pressure of 760 mmHg. Calculate the percentage of cyclohexane in the distillate. (The vapour pressure of water at 98°C is 655 mmHg, $\text{C} = 12$, $\text{H} = 1$, $\text{O} = 16$) *(03 marks)*
- (c) Nitric acid and water form a non-ideal solution that deviates from Raoult's law. The table below shows the composition of nitric acid in liquid and vapour phases at different temperatures.

Temp ($^{\circ}\text{C}$)		90	96	101	103	104	106	110	113	116	119	120	121
Percentage of nitric acid	Liquid	93	85	09	18	78	30	43	71	59	66	67	68
	Vapour	98	96	01	03	90	08	20	81	40	53	58	68

- (i) Plot a well-labelled boiling point composition diagram for the nitric acid – water system. (The boiling points of nitric acid and water are 86°C and 100°C respectively.) *(05 marks)*
- (ii) Explain why the mixture of nitric acid and water shows the type of deviation in the diagram in (i) above. *(04 marks)*
- (iii) Describe what happens when a liquid mixture containing 40% of nitric acid is fractionally distilled. *(3½ marks)*

8. Explain the following observations.

- (a) A mixture of 50cm^3 of 0.1 M ammonium hydroxide solution and 50cm^3 of 0.1M hydrochloric acid gives a resultant solution whose pH is less than 7. *(4½ marks)*
- (b) The solubility of lithium chloride in ethanol is higher than solubility of potassium chloride in ethanol. *(03 marks)*
- (c) When iodine crystals are added to cold dilute sodium hydroxide solution, grey solid dissolves to a pale yellow solution which turned colourless on standing. *(04 marks)*
- (d) When carbon dioxide was bubbled through an aqueous solution of potassium manganate(VII) solution, the green solution turned purple and a black precipitate was formed. *(04 marks)*
- (e) When methanoic acid was warmed with Fehling's solution, a red precipitate was formed whereas with ethanoic acid, there was no observable change. *(4½ marks)*