

P525/2
CHEMISTRY
Paper 2
(Theory)
Nov./Dec. 2023
2½ hours



UGANDA NATIONAL EXAMINATIONS BOARD
Uganda Advanced Certificate of Education

CHEMISTRY

Paper 2
(Theory)

2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES:

Answer five questions including three questions from section A and any two from section B.

Write the answers in the answer booklet(s) provided.

Begin each question on a fresh page.

Mathematical tables and squared paper are provided.

Silent non-programmable scientific electronic calculators may be used.

Use equations where necessary to illustrate your answers.

Where necessary use the following:

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

SECTION A (60 MARKS)

Answer any **three** questions from this section.

Any additional question answered will **not** be marked.

1. (a) Define the terms **homogeneous** and **heterogeneous** systems. (02 marks)
- (b) Ammonia can be formed according to the following equation:
$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g); \Delta H = -92.4 \text{ kJ mol}^{-1}$$
- (i) Derive an expression to show the relationship between K_p and K_c . (03 marks)
- (ii) Explain how the position of equilibrium of the system can be affected by temperature and pressure. (06 marks)
- (c) The esterification of ethanol by ethanoic acid is a reversible reaction.
- (i) Write an equation and the expression for the equilibrium constant for the reaction. (02 marks)
- (ii) When 1.0 mole of ethanoic acid and 1.0 mole of ethanol were reacted in a 1.0 dm³ vessel, 0.67 moles of ethylethanoate and 0.67 moles of water were formed. Calculate the equilibrium constant at this temperature. (02 marks)
- (iii) 1.5 moles of ethanoic acid were reacted with 2.0 moles of ethanol under similar conditions as in (c)(ii). Calculate the mass of the ethylethanoate formed. (05 marks)
2. Compounds W, X, Y and Z with molecular formulae C_3H_8O , C_3H_6O , C_4H_6 and C_2H_7N respectively, react as follows;
- W gives white fumes of hydrogen chloride with phosphorus(V) chloride,
X gives an orange precipitate with 2,4 - dinitrophenylhydrazine,
Y decolourises bromine water slowly and
Z dissolves in water to give an alkaline solution.
- (a) For each of the compounds;
- (i) identify the functional group. (04 marks)
- (ii) write the structural formulae of two possible isomers. (04 marks)
- (b) Write a mechanism for the reaction of one of the isomers of X with 2,4 - dinitrophenylhydrazine. (06 marks)

- (c) Name **one** reagent that can be used to differentiate between the isomers of the following compounds, and in each case state what would be observed if each of the isomers was treated with the reagent you have named: (06 marks)

- (i) W.
(ii) Z.

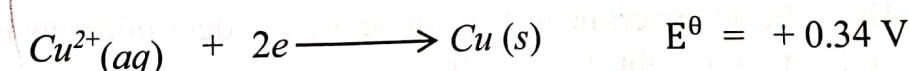
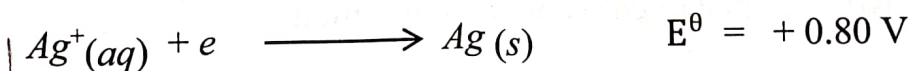
3. (a) State what is meant by the term **eutectic mixture**. (01 mark)

- (b) Table 1 shows how the melting points of mixtures of copper and silver vary with composition.

Table 1

Percentage of copper in the mixture	0	20	40	70	80	100
Melting point (°C)	961	830	830	960	1000	1085

- (i) Draw a fully labelled diagram for the copper-silver system. (05 marks)
- (ii) Determine the eutectic temperature and the composition of the eutectic mixture. (1½ marks)
- (c) Describe the changes that would take place when a liquid mixture of the above system containing 50 % copper is cooled from 1000 °C to 700 °C. (4½ marks)
- (d) Equations for some half-cell reactions are shown below.



- (i) Write an equation for the overall cell reaction. (01 mark)
- (ii) Calculate the E^θ_{cell} in (d)(i). (01 mark)
- (iii) Calculate the Gibb's free energy of the cell and state whether the reaction is feasible or not. Give a reason for your answer. (02 marks)
- (1F = 96500 C)
- (e) Discuss the reaction of copper with sulphuric acid. (04 marks)

4. Cobalt, copper, iron and manganese are d-block elements.

- (a) State what is meant by the term **d-block element**. (01 mark)
- (b) (i) Write the electronic configurations of copper, iron(II) ions and manganese(II) ions. (1½ marks)
- (The atomic number of manganese, iron and copper are 25, 26 and 29 respectively.)

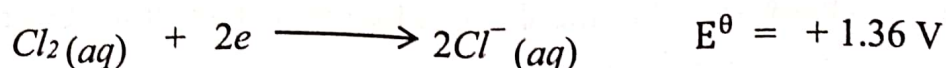
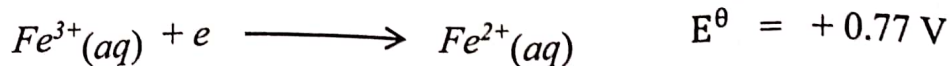
- (ii) Explain why iron(II) ions are readily oxidised to iron(III) ions but manganese(II) ions are not readily oxidised to manganese(III) ions. (5½ marks)
- (c) (i) Write the formula of a compound or ion in which manganese is in the oxidation state of +7. (01 mark)
- (ii) Explain why it is possible for manganese to form compounds or ions in which manganese is in the +7 oxidation state. (02 marks)
- (d) Explain each of the following observations:
- (i) Manganese can be magnetised whereas copper can **not**. (04 marks)
- (ii) Iron is used as a catalyst in many reactions. (02 marks)
- (f) State **three** properties of cobalt which show that it is a transition element and give **one** example in each case. (03 marks)

SECTION B (40 MARKS)

*Answer any two questions from this section.
Any additional question(s) answered will **not** be marked.*

5. (a) Define each of the following terms:
- (i) Molar enthalpy of combustion. (01 mark)
- (ii) Standard enthalpy of atomisation. (01 mark)
- (b) Describe an experiment that can be used to determine the molar enthalpy of combustion of ethanol. (10 marks)
(Your answer should include treatment of results but not diagram;
Specific heat capacity of water = $4.2 \text{ Jg}^{-1}\text{K}^{-1}$)
- (c) Carbon burns in air to produce carbon monoxide and carbon dioxide. The enthalpy of combustion of carbon is -393 kJ mol^{-1} and that of carbon monoxide is -283 kJ mol^{-1} .
- (i) Construct a Born Haber cycle to show reactions leading to enthalpies of combustion of carbon, carbon monoxide and formation of carbon dioxide. (03 marks)
- (ii) Using the diagram in (c) (i), calculate the enthalpy of formation of carbon monoxide. (02 marks)
- (d) How is enthalpy change used to predict the feasibility of a reaction? (03 marks)

6. (a) The E^θ for some half-cell reaction are shown below.



Explain what would be observed if to a solution containing iron(II) ions was added aqueous chlorine followed by dilute sodium hydroxide solution. (06 marks)

- (b) Explain what would be observed if excess potassium iodide was added to aqueous copper(II) sulphate and the mixture shaken with hexane. (05 marks)

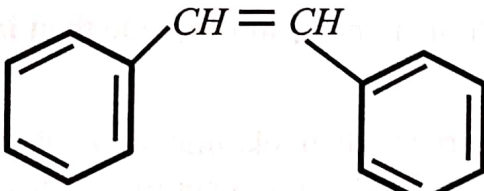
- (c) The colour of dilute copper(II) sulphate is blue but when excess concentrated hydrochloric acid is added to it, it changes to yellow. Explain. (3½ marks)

- (d) Explain why chromium hydroxide reacts with both dilute hydrochloric acid and sodium hydroxide solutions. (5½ marks)

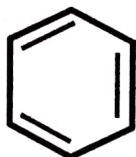

7. Write equations to show how each of the following compounds can be synthesised. Indicate reagents and conditions for the reactions in each case.

- (a) CH_4 from $CH_2 = CH_2$. (03 marks)

- (b) $CH_3CH_2NH_2$ from CH_3OH . (05 marks)

- (c)  from benzene. (04 marks)

- (d) $CH_3CH_2CH_2COOH$ from $CH_3CH=CH_2$. (4½ marks)

- (e)  from . (3½ marks)

8. Fluorine, chlorine, bromine and iodine are elements in group (VII) of the Periodic Table.

- (a) Explain why fluorine shows differences in its properties from the rest of the elements. (2½ marks)
- (b) With the exception of fluorine, describe a general method for preparing the elements in group (VII) in the laboratory and write the equations for the reactions. (3½ marks)
- (c) The lattice energies of silver halides are shown in table 2.

Table 2

Silver halide	Lattice energy (kJmol ⁻¹)
<i>AgF</i>	-943
<i>AgCl</i>	-890
<i>AgBr</i>	-877
<i>AgI</i>	-867

Explain the trend in the lattice energy. (3½ marks)

- (d) Explain why;
- (i) chlorine is more soluble in dilute sodium hydroxide solution than water. (04 marks)
- (ii) iodine is more soluble in potassium iodide than in water. (4½ marks)
- (e) State what would be observed when alkaline iodine is added to butanone and write an equation for the reaction that takes place. (02 marks)