P525/2
CHEMISTRY
(Theory)
Paper 2
Nov./Dec.2022
2½ hours

UGANDA NATIONAL EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

CHEMISTRY
(THEORY)

Paper 2

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, Ag=108, Cl=35.5]

SECTION A (60 MARKS)

Answer **three** *questions from this section.*
Any additional question answered will **not** *be marked.*

1. (a) State what is meant by the term **order of a reaction**. *(01 mark)*

(b) The decomposition of hydrogen peroxide proceeds according to the following equation:

$2H_2O_2\,(aq) \longrightarrow 2H_2O(l) + O_2\,(g)$.

(i) Write the expression for the rate law of the reaction. *(1½ marks)*

(ii) Describe how the order of the reaction can be determined. *(05 marks)*

(iii) Explain the effect of temperature on the rate of decomposition of hydrogen peroxide. *(3½ marks)*

(c) The following kinetic data in table **1** were obtained for the decomposition of hydrogen peroxide.

Table 1

Concentration of H_2O_2 (mol dm^{-3})	1.6×10^{-3}	1.3×10^{-3}	7.6×10^{-4}	3.6×10^{-4}	1.4×10^{-4}	1.0×10^{-4}
Time (minutes)	0	5	12	20	33	40

Plot a graph of concentration of hydrogen peroxide against time. *(04 marks)*

(d) Using your graph, determine the time required for;

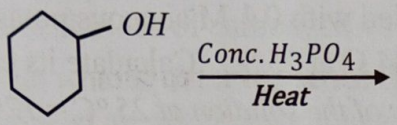
(i) 1.0×10^{-3} moles of hydrogen peroxide to reduce to 5.0×10^{-4} moles. *(01 mark)*

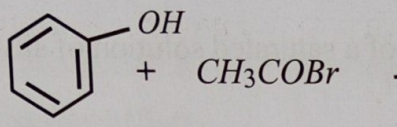
(ii) 6.0×10^{-4} moles of hydrogen peroxide to reduce to 3.0×10^{-4} moles. *(01mark)*

(e) (i) What conclusions can be drawn from your answers in (d) (i) and (ii)? *(1½ marks)*

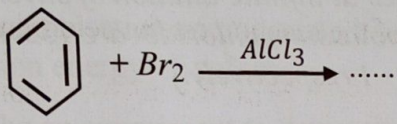
(ii) Determine the rate constant for the reaction. *(1½ marks)*

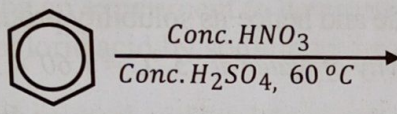
2. Complete the following equations and in each case, write mechanisms for the reactions:

(a)  ..... *(04 marks)*

(b)  ..... *(4½ marks)*

(c) $CH_3CHClCH_3 \xrightarrow[\textbf{Heat}]{CH_3ONa/ethanol}$ ..... *(03 marks)*

(d)  ..... *(3½ marks)*

(e)  ..... *(05 marks)*

3. (a) Although the elements: fluorine, chlorine, bromine and iodine belong to group (VII) of the Periodic Table, fluorine behaves differently from the rest of the group members. State;

(i) **two** reasons why flourine differs from the other elements of group (VII). *(01 mark)*

(ii) any **two** reactions in which fluorine differs from the other elements of group (VII) and write equations to illustrate your answers. *(06 marks)*

(b) The atomic numbers of some group (VII) elements and the boiling points of their hydrides are shown in table **2**.

Table 2

Element	**F**	**Cl**	**Br**	**I**
Atomic Number	9	17	35	53
Formula of the hydride	HF	HCl	HBr	HI
Boiling point of hydride (^{O}C)	+19.9	–85.0	–66.7	–35.4

(i) Plot a graph of boiling points of the hydrides against atomic numbers of the elements. *(04 marks)*

(ii) Explain the shape of your graph. *(4½ marks)*

(c) State what would be observed and write an equation for the reaction that would take place if;

(i) sodium thiosulphate solution was added to iodine solution. *(2½ marks)*

(ii) chlorine gas was bubbled through a solution of potassium bromide. *(02 marks)*

4. (a) (i) State the difference between molar conductivity and electrolytic conductivity of a solution. *(01 mark)*

(ii) A conductivity cell filled with 0.1 M aqueous potassium chloride gave a resistance of 484 Ω at 25 °C. Calculate its cell constant.
(The molar conductivity of the solution at 25 °C = 129 Ω^{-1} cm^2 mol^{-1}).
(3½ marks)

(b) The electrolytic conductivity of a saturated solution of silver chloride at 25 °C is 3.41×10^{-6} Ω^{-1} cm^{-1}.

Calculate the;

(i) molar conductivity of silver chloride at infinite dilution. *(1½ marks)*
(The molar conductivities at infinite dilution of silver nitrate, potassium nitrate and potassium chloride are 133.4, 145.0 and 149.9 $\Omega^{-1} cm^2 mol^{-1}$ respectively.)

(ii) solubility of silver chloride and hence its solubility product. *(7½ marks)*
(The electrolytic conductivity of water at 25 °C = 1.60×10^{-6} $\Omega^{-1} cm^{-1}$).

(c) Explain the effect of each of the following factors on the molar conductivity of an electrolyte:

(i) ionic radius. *(2½ marks)*
(ii) concentration. *(04 marks)*

SECTION B (40 MARKS)

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

5. The melting points and atomic numbers of some elements of group (IV) of the Periodic Table are shown in table 3.

Table 3

Element	Carbon	Silicon	Germanium	Tin	Lead
Atomic number	6	14	32	50	82
Melting point (°C)	3750	1420	950	232	327

(a) (i) Explain the trend in the melting points of the elements. *(05 marks)*
(ii) Describe the reaction of the elements with sulphuric acid. *(07 marks)*

(b) Group (IV) elements form tetrachlorides.

(i) Write equations for the reactions leading to the formation of the tetrachlorides of carbon, silicon and lead. *(4½ marks)*

(ii) State what is observed when the tetrachlorides of carbon, silicon and lead are reacted with water. Explain your observations. *(3½ marks)*

6. (a) State what is meant by the following terms:

(i) electron affinity. *(01 mark)*

(ii) first ionisation energy. *(01 mark)*

(iii) enthalphy of solution. *(01 mark)*

(b) The first ionisation energy of an element is always less than the second ionisation energy. Explain. *(02 marks)*

(c) Describe an experiment to determine the enthalpy of neutralisation of hydrochloric acid by sodium hydroxide. *(05 marks)*

(d) Some thermo-chemical data about calcium and oxygen are shown below.

Process	**Energy (kJ mol^{-1})**
Enthalpy of formation of calcium oxide	= − 636.0
Enthalpy of Sublimation of calcium	= + 177.0
First ionisation energy of calcium	= + 590.0
Second ionisation energy of calcium	= + 1100.0
Bond dissociation energy of oxygen	= + 498.0
First electron affinity of oxygen	= − 141.4
Second electron affinity of oxygen	= + 790.8

(i) Draw an energy level diagram for the formation of calcium oxide. *(04 marks)*

(ii) Calculate the lattice energy of calcium oxide. *(02 marks)*

(iii) Comment on the stability of calcium oxide. *(01 mark)*

(e) The hydration and lattice energies for the chlorides of lithium and sodium are shown in table **4**.

Table 4

Compound	Lattice energy ($kJ\ mol^{-1}$)	Hydration energy ($kJ\ mol^{-1}$)
LiCl	843	883
NaCl	778	775

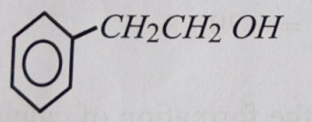
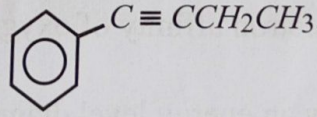
(i) Calculate the enthalpies of solution for lithium chloride and sodium chloride. *(1½ marks)*

(ii) Which one of the chlorides in (e) (i) is likely to dissolve more on heating? Explain your answer. *(1½ marks)*

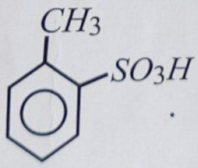
7. Write equations to show how the following conversions can be effected, indicate reagents and conditions for the reaction in each case.

(a) $CH_3\overset{\overset{O}{\|}}{C}CH_3$ to $CH_3CH_2\,CH_2OH$. *(5½ marks)*

(b) CH_3CH_2I to $CH_3CH_2\,COOH$. *(2½ marks)*

(c)  to  *(5½ marks)*

(d) $CH_3\overset{\overset{Br}{|}}{C}HCH_2\,CH_3$ to $CH_3\overset{\overset{O}{\|}}{C}CH_2\,CH_3$. *(2½ marks)*

(e) $HC{\equiv}CH$ to  *(04 marks)*

8. Explain each of the following observations and illustrate your answer with equations where necessary.

(a) The reactivity of alcohols with hydrogen halides is in the order; tertiary > secondary > primary alcohol. *(2½ marks)*

(b) Alcohols are neutral organic compounds whereas phenol is weakly acidic, and yet both have hydroxyl group. *(04 marks)*

(c) Magnesium ions form a precipitate with dilute ammonia solution, but no precipitate is formed if ammonium chloride is added to magnesium ions prior to ammonia solution. *(06 marks)*

(d) Water boils at 100 °C whereas hydrogen fluoride boils at 19.5 °C although both compounds exhibit hydrogen bonding. *(04 marks)*

(e) The nitronium ion, NO_2^+ has a linear shape whereas the nitrite ion, NO_2^- is V - shaped. *(3½ marks)*

END