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:
   $[H=1;\ C=12;\ O=16, Ag=108, Cl=35.5\ ]$

Turn Over

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*)

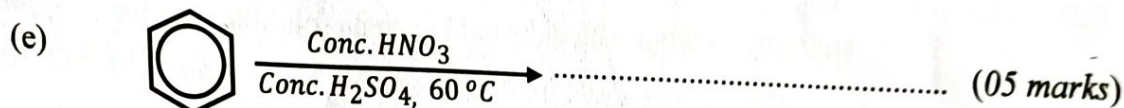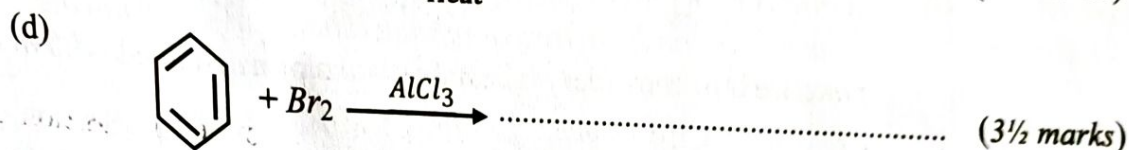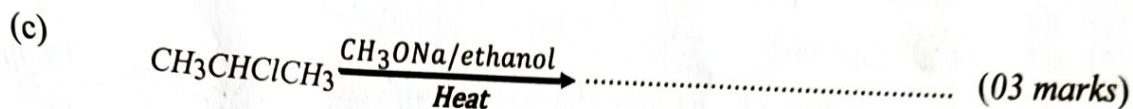   (c) The following kinetic data in table **1** were obtained for the decomposition of hydrogen peroxide.
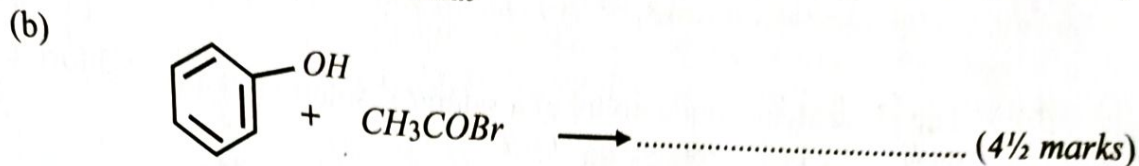
   Table 1

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*)

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

(a)

$$\xrightarrow[\text{Heat}]{Conc. H_3PO_4}$$ .... (04 marks)

(b)

$+ \quad CH_3COBr \longrightarrow$ .... (4½ marks)

(c)

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

(d)

$+ Br_2 \xrightarrow{AlCl_3}$ .... (3½ marks)

(e)

$$\xrightarrow{Conc. HNO_3 \atop Conc. H_2SO_4, \ 60\,^oC}$$ .... (05 marks)
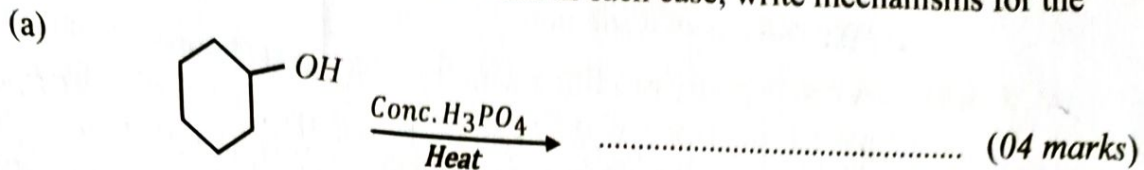
3. (a) Although the elements: fluorine, chlorine, bromine and iodine belong to group (VII) of the Periodic Table, fluorine behaves differently from the rest of the group members. State;

(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 (^oC)	+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)

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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 x 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 Ω^{-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} Ω^{-1} cm^{-1}).*

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

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

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(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.

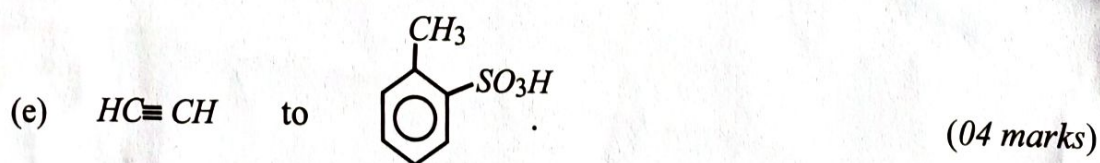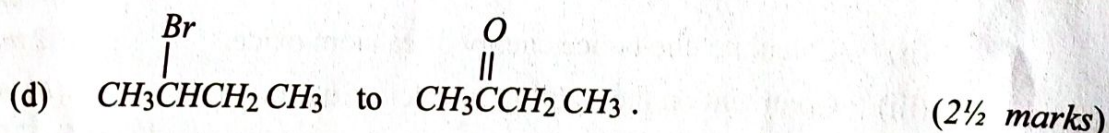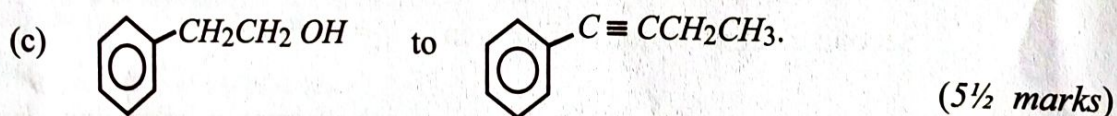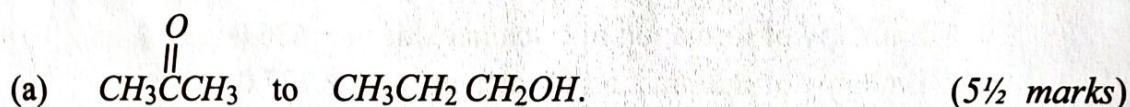| Process	Energy (kJ mol⁻¹)
Enthalpy of formation of calcium oxide	$= -636.0$
Enthalpy of Sublimation of calcium	$= +177.0$
First ionisation energy of calcium	$= +590.0$
Second ionisation energy of calcium	$= +1100.0$
Bond dissociation energy of oxygen	$= +498.0$
First electron affinity of oxygen	$=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

458
224
$O_2 \longrightarrow 2O$

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

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

(c) $-CH_2CH_2\,OH$ to $-C\equiv CCH_2CH_3$. *(5½ marks)*

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

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

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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