P525/2
CHEMISTRY
(Theory)
Paper 2
Nov./Dec. 2019
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;]

SECTION A (60 MARKS)

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

1. (a) The atomic numbers of scandium and manganese are 21 and 25 respectively. Write the electronic configuration of:

    (i)   Scandium.   *(01 mark)*
    (i)   Manganese.   *(01 mark)*
    (i)   Scandium(III) ion.   *(01 mark)*
    (ii) Manganese(VII) ions.   *(01 mark)*

    (b) Explain why scandium only forms compounds in which it's oxidation state is +3, while manganese forms compounds in which its oxidation states are +2 and +7.   *(03 marks)*

    (c) Potassium hydroxide was fused with manganese(IV) oxide in the presence of oxygen to form a green solid X. Solid X dissolved in water to form a green solution. On bubbling carbon dioxide gas through the green solution, a purple solution Y and a brown solid were formed.

    (i)   Name solid X and write equation for the reaction leading to the formation of X.   *(2½ marks)*

    (ii) Write equation leading to the formation of solution Y. *(1½ marks)*

    (d) When sulphur dioxide was bubbled through acidified solution Y, the colour of the solution turned from purple to colourless. Explain.

                                                    (3½ marks)

    (e) State what would be observed and write equation for the reaction that would take place if to the resultant solution in (d) was added;

    (i)   dilute sodium hydroxide solution.   *(03 marks)*
    (ii) acidified barium nitrate solution.   *(2½ marks)*

2. (a) (i) Explain what is meant by the term **partition coefficient**? *(02 marks)*
         (ii) State **four** conditions under which partition law is valid. *(02 marks)*

    (b) (i) Describe an experiment to determine the partition coefficient of iodine between ether and water.   *(06 marks)*

         (ii) Give **four** reasons why ethoxyethane (ether) is most commonly used in solvent extraction of organic compounds from their aqueous solution.   *(02 marks)*

(c) The partition coefficient of a substance Z between methylbenzene and water is 12. Calculate the mass of Z that will be extracted from 200 cm^3 of an aqueous solution containing 8.0 g of Z, by:

    (i) shaking with 50 cm^3 of methylbenzene. *(02 marks)*

    (ii) shaking successively with two separate 25 cm^3 – portions of methyl benzene. *(04 marks)*

    (iii) comment on your answers in (i) and (ii). *(01 mark)*

(d) State **two** applications of partition law other than solvent extraction. *(01 mark)*

3. (a) The boiling points of 2-chlorobutane and 2-iodobutane are 68 °C and 119 °C respectively. When treated separately with aqueous sodium hydroxide, followed by acidified silver nitrate solution, 2-chlorobutane forms a white precipitate after about 15 minutes, whereas 2-iodobutane forms a white precipitate almost immediatley.

Explain;

    (i) Why the boiling point of 2-chlorobutane is lower than that of 2-odobutane. *(02 marks)*

    (ii) The formation of the white precipitate in 2-chlorobutane takes a longer time than in 2-iodobutane. *(03 marks)*

(b) Write;

    (i) equation for the reaction of 1-chlorobutane with aqueous sodium hydroxide. *(01 mark)*

    (ii) the mechanism for the reaction in (b)(i). *(01 mark)*

(c) The reaction in (b)(i) is exothermic. Sketch a labelled potential energy versus reaction co-ordinate diagram for the reaction. *(2½ marks)*

(d) (i) Write equation for the conversion of benzene to chlorobenzene. *(01 mark)*

    (ii) Outline a mechanism for the reaction in (d)(i). *(03 marks)*

(e) Write equation(s) to show how 2-bromobutane can be converted to butanone. *(2½ marks)*

(f) (i) Name **one** reagent that would be used to confirm the formation of butanone. *(01 mark)*

    (ii) State what would be observed if butanone was present. *(01 mark)*

    (iii) Write equation for the reaction of butanone and the reagent you have named in (f)(i). *(01 mark)*

(g)   A solution containing iodine and sodium hydroxide was added to butanone. State what was observed. (*01 mark*)

4.   (a)   (i)   Define the term **standard enthalpy change** of a reaction. (*01 mark*)

(ii)   Briefly, describe how the enthalpy of neutralisation of nitric acid by sodium hydroxide can be determined. (*05 marks*)

(iii)   Explain why the enthalpy of neutralisation of sodium hydroxide by nitric acid is 57.1 kJ mol^{-1} whereas the enthalpy of neutralisation of sodium hydroxide by hydrocyanic acid is 12.0 kJ mol^{-1}. (*02 marks*)

(b)   The heat change that takes place when one mole of gaseous ion is completely dissolved in enough solvent is called hydration energy.

State the factors that affect hydration energy and explain their effects. (*04 marks*)

(c)   The standard enthalpies of hydration and lattice energies of lithium chloride and potassium chloride are given in Table **1**.

Table 1

Salt	Lattice energy (kJ mol^{-1})	Hydration energy (kJ mol^{-1})
Potassium chloride	−862	−883
Lithium chloride	−718	−695

(i)   Calculate the enthalpy of solution of lithium chloride and potassium chloride. (*2½ marks*)

(ii)   State which one of the two salts would be more soluble in water at a given temperature and give a reason for your answer. (*01 mark*)

(a)   Using the thermochemical data below, determine the lattice energy of sodium chloride. (*4½ marks*)

Heat of atomisation of sodium = 108 kJ mol^{-1}

Dissociation energy of chlorine = 242.2 kJ mol^{-1}

Ionisation energy of sodium = 500 kJ mol^{-1}

Electron affinity of chlorine = −364 kJ mol^{-1}

Enthalpy of formation of sodium chloride = −411.3 kJ mol^{-1}

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

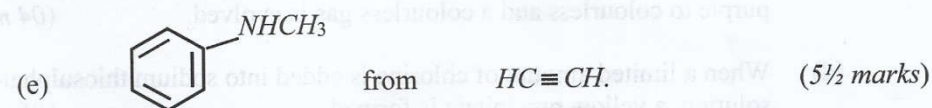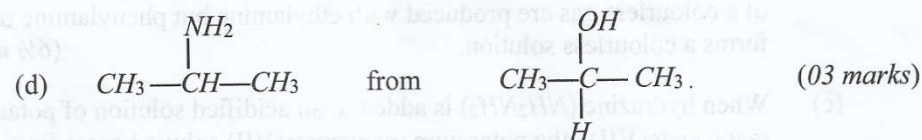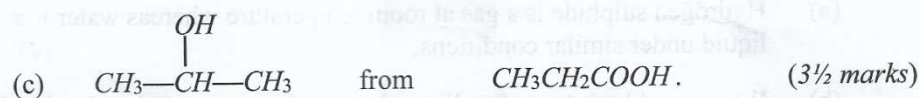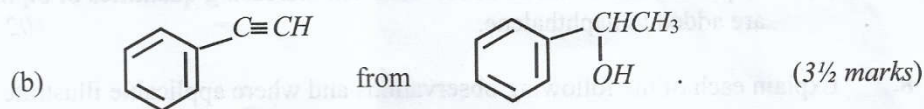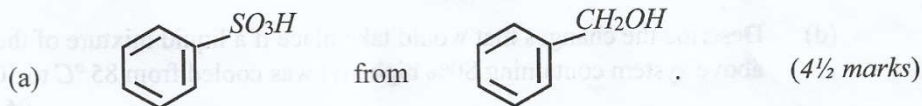5. (a) Carbon, silicon, tin and lead are some of the elements in group (IV)
         of the Periodic Table.

         Discuss the reactivity of the elements with;

         (i)   water,   (*04 marks*)
         (ii)   sodium hydroxide solution,   (*06 marks*)
         (iii) concentrated sulphuric acid.   (*7½ marks*)

    (b) State what would be observed and write equation for the reaction that
         would take place if excess concentrated hydrochloric acid was mixed
         with lead(IV) oxide and heated.   (*2½ marks*)

6. Write equations to show how the following compounds can be synthesized.

    (a) [benzene ring with SO_3H] from [benzene ring with CH_2OH] .   (*4½ marks*)

    (b) [benzene ring with $C \equiv CH$] from [benzene ring with $CHCH_3$ / OH] .   (*3½ marks*)

    (c) $CH_3-CH-CH_3$ with OH from CH_3CH_2COOH .   (*3½ marks*)

    (d) $CH_3-CH-CH_3$ with NH_2 from CH_3-C-CH_3 with OH and H .   (*03 marks*)

    (e) [benzene ring with $NHCH_3$] from $HC \equiv CH$.   (*5½ marks*)

Turn Over

7.   (a)   Define the term **eutectic mixture**? (*01 mark*)

     (b)   Briefly, describe how a phase diagram of a mixture of biphenyl and naphthalene can be determined in the laboratory. (*03 marks*)

     (c)   Table 2 shows the melting points of various mixtures of naphthalene – biphenyl.

Table 2

Mole fraction of naphthalene	0.125	0.275	0.450	0.625	0.800
Melting point (°C)	58.0	47.0	40.0	53.0	68.0

            (i)   Draw a fully labelled diagram of the naphthalene- biphenyl system. (*The melting of naphthalene and biphenyl are 80 °C and 71 °C respectively.*) (*05 marks*)

            (ii) Determine the eutectic temperature and the composition of the eutectic mixture. (*03 marks*)

     (d)   Describe the changes that would take place if a liquid mixture of the above system containing 80% biphenyl was cooled from 85 °C to 30 °C. (*06 marks*)

     (e)   Explain what would be observed when increasing quantities of biphenyl are added to naphthalene. (*02 marks*)

8.   Explain each of the following observations and where applicable illustrate your answer with equation(s):

     (a)   Hydrogen sulphide is a gas at room temperature whereas water is a liquid under similar conditions. (*4½ marks*)

     (b)   When a cold mixture of sodium nitrite and concentrated hydrochloric acid solution is added separately to ethylamine and phenylamine, bubbles of a colourless gas are produced with ethylamine but phenylamine only forms a colourless solution. (*6½ marks*)

     (c)   When hydrazine (NH_2NH_2) is added to an acidified solution of potassium manganate(VII), the potassium manganate(VII) solution turns from purple to colourless and a colourless gas is evolved. (*04 marks*)

     (d)   When a limited amount of chlorine is added into sodium thiosulphate solution, a yellow precipitate is formed. (*05 marks*)