THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN ANALYTICAL CHEMISTRY

MODULE I

ORGANIC AND INORGANIC CHEMISTRY

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:
  Answer booklet;
  Non-programmable scientific calculator.
This paper consists of TWO sections; A and B.
Answer ALL questions in section A and any THREE questions from section B.
Each question in section A carries 4 marks while each question in section B carries 20 marks.
Maximum marks for each part of the question are indicated.
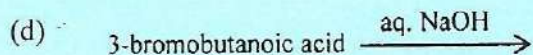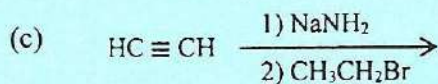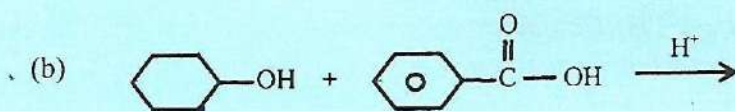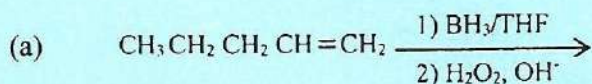***Candidates should answer the questions in English.***

This paper consists of **6 printed pages.**

Candidates should check the question paper to ascertain that
all the pages are printed as indicated and that no questions are missing.

Turn over

Answer ALL questions in this section.

1. Give any four characteristics of the mechanism of free radical halogenation chain reaction.
   (4 marks)

2. (a) Write structural formula of each of the following compounds:

   (i) methoxyethane. (1 mark)

   (ii) neopentane (1 mark)

   (b) Give the IUPAC names of the following compounds:-

   (i) $(CH_3)_2 C(COOH)_2$ (1 mark)

   (ii) $CH_3 CHI CH(CH_2)_3CH_3$ (1 mark)
   $\qquad\qquad\quad |$
   $\qquad\qquad\ C\equiv CH$

3. (a) Using equation, show how butane can be prepared from chloroethane using the Wurtz synthesis. (1 mark)

   (b) Why is the Wurtz synthesis not a good method for preparing propane? (2 marks)

   (c) State **one** limitation of Wurtz reaction. (1 mark)

4. Complete the following reactions by giving structure of the major organic product.

   (a) $CH_3CH_2 CH_2 CH=CH_2 \xrightarrow[\text{2) } H_2O_2,\ OH^-]{\text{1) } BH_3/THF}$

   (b) $\xrightarrow{H^+}$

   (c) $HC\equiv CH \xrightarrow[\text{2) } CH_3CH_2Br]{\text{1) } NaNH_2}$

   (d) 3-bromobutanoic acid $\xrightarrow{\text{aq. NaOH}}$

   (4 marks)

5. State **four** limitations of Grignard reaction. (4 marks)

6. Give the s, p, d- notation for the following chemical species:-

   (a) O^{2-} ;

   (b) Cr ;

   (c) Zn^{2+} ;

   (d) Copper .
   [O=8, Cr=24, Zn=30, Cu=29]

   (4 marks)

7. (a) Name the Group 1 metal whose compounds gives a lilac flame colour. (1 mark)

   (b) Explain the origin of flame colours (3 marks)

8. Explain the following observations:-

   (a) Usually the first ionization energy of elements increases with the atomic number of the periodic table. (2 marks)

   (b) H_2S and H_2O boils at -60 °C and 100 °C respectively. (2 marks)

9. (a) Explain the contributions made by Lothar Meyer's in the historical development of the periodic table. (2 marks)

   (b) State two limitations of Mendeleev periodic table. (2 marks)

10. Describe the diagonal relationship between Lithium and Magnesium. (4 marks)

SECTION B (60 marks)

Answer ANY THREE questions in this section.

11. (a) On heating with concentrated sulphuric acid, Butan-2-ol is converted into a mixture of alkenes.

    (i) Name the type of reaction taking place. (1 mark)

    (ii) Give the structural formula of the alkenes formed. (2 marks)

    (b) Give the name and the structural formula of the organic compound produced when butan-1-ol is heated with acidified potassium dichromate (VI). (2 marks)

(c) When 2-methylpropan-2-ol is heated with carboxylic acid in the presence of a catalyst, an ester is formed.

    (i)   Write the equation of the reaction involved.   (2 marks)

    (ii)   Draw the structural formula of the ester.   (1 mark)

(d) A mixture of anhydrous zinc chloride and concentrated hydrochloric acid is warmed with three alcohols; butan-1-ol, butan-2-ol and 2-methylpropan-2-ol under identical conditions. Describe how the above alcohols can be distinguished using the given reagents.   (6 marks)

(e) Under appropriate reaction conditions, 2-bromo-3-methylbutane can be converted into an alcohol.

    (i)   Name the type of reaction taking place.   (1 mark)

    (ii)   Give the role of the reagent potassium hydroxide when it reacts with 2-bromo-3-methylbutane.   (1 mark)

    (iii)   Draw the structure of the alcohol.   (1 mark)

    (iv)   Outline a mechanism for the reaction   (3 marks)

12. (a) (i) Draw **all** the possible structural isomers, of the compound with molecular formula C_4H_9Br.   (4 marks)

    (ii)   Give the IUPAC names of the isomers in (a) (i) above.   (4 marks)

    (iii)   Name the type of reaction(s) of the isomers with ammonia.   (1 marks)

    (iv)   (i)   Select the most reactive isomer.   (1 mark)

         (II)   Give reason(s) for the answer in (iv) (I) above.   (1 mark)

(b) Ethene reacts with bromine to give 1, 2-dibromoethane:

    (i)   Name the mechanism involved.   (1 mark)

    (ii)   Illustrate the mechanism for the reaction in (b) (i) above.   (6 marks)

(c) Define the term spirane and give two examples of spirooctanes.   (2 marks)

13.   (a)   Write the overall equation and the propagation steps of the mechanism for the chlorination of chloromethane to yield dichloromethane.   (3 marks)

    (b)   Name the following alkenes.

      (i)   (1½ marks)

$$\underset{H}{\overset{Cl}{\diagdown}} C = C \underset{H}{\overset{Cl}{\diagup}}$$

      (ii)   (1½ marks)
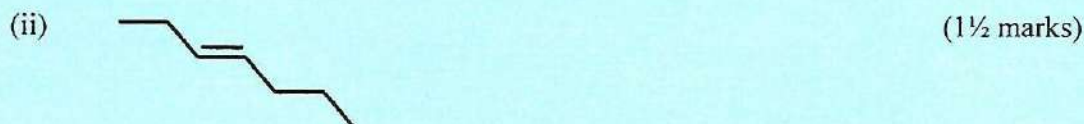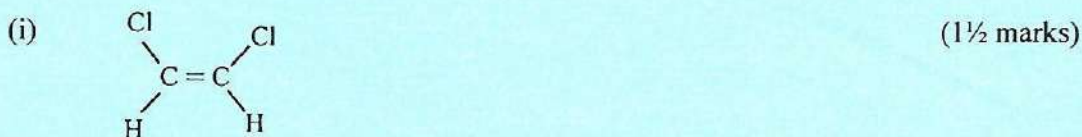
    (c)   State any **two** uses of

      (i)   ethanol.   (2 marks)

      (ii)   ethyne.   (2 marks)

    (d)   In Rutherfold's experiments, generally the thin foil of heavy atoms like gold are bombared by α particles.

      (i)   Describe the principle of Rutherfold's experiment.   (4 marks)

      (ii)   If a thin foil of light atoms like in aluminium was used instead of gold, state the observation that would be made.   (2 marks)

    (e)   An atomic orbital has n=3. List the possible values of l and ml.   (4 marks)

14.   (a)   State the fundamental particles of an atom and give their charges.   (4 marks)

    (b)   State:

      (i)   Hund's Rule.   (2 marks)

      (ii)   Paulis exclusion principle.   (2 marks)

    (c)   Apply Hund's rule to show how electrons are filled into the orbitals of:

      (i)   Nitrogen ;

      (ii)   Sulphur ;

      (iii)   Potassium ;

      (iv)   Iron atoms .

[N=7, S=16, K=19, Fe=26]   (4 marks)

(d) Using dot(.) and cross (x) diagrams, show the bonding in the following molecules:-

    (i) Hydrogen molecule. (1 mark)

    (ii) Hydrogen chloride molecule. (1 mark)

    (iii) Ammonia. (1 mark)

    (iv) Nitrogen gas. (1 mark)

(e) Use electron pair repulsion theory to determine the shapes of the following molecules:

    (i) Water (2 marks)

    (ii) BCl_3 (2 marks)

15. (a) With a well labelled diagram, describe the discharge tube experiment. (10 marks)

    (b) Determine the energy that will be required to make an electron move from the ground state (n=1) of the hydrogen atom to the level with n=5 (h=6.626×10^{-34} J.S, R_4=1.098×10^7m) (4 marks)

    (c) (i) Why are alkali metal ions very difficult to reduce to the metals? (2 marks)

       (ii) Write equation for the effect of heat on the following salts:-

           I. $NaHCO_3$ (1 mark)

           II. Limestone. (1 mark)

           III. Potassium nitrate (1 mark)

    (d) State **one** use of Li_2CO_3 (1 mark)

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