P525/2
CHEMISTRY
(Theory)
Paper 2
Nov./Dec. 2020
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.

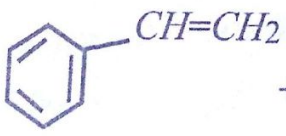*Silent non-programmable scientific electronic calculators may be used.*

Use equations where necessary to illustrate your answers.

Where necessary use the following:

  [H=1; C= 12; N=14; O=16].

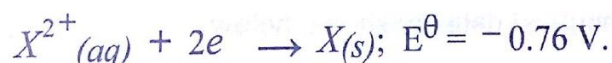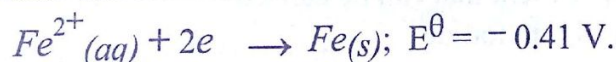**Turn Over**

SECTION A (60 MARKS)

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

1. (a) Explain what is meant by the term;

       (i)   pH. *(03 marks)*

       (ii)   buffer solution. *(03 marks)*

  (b) State **two** practical applications of buffer solutions. *(01 mark)*

  (c) Calculate the pH of a;

       (i)   0.1 M aqueous ethanoic acid. *(3½ marks)*

       (ii)   buffer solution made by dissolving 16.4 g of sodium ethanoate, CH_3COONa in 1 dm^3 of a 0.1 M ethanoic acid.
(The dissociation constant, K_a of ethanoic acid is 1.75×10^{-5} mol dm^{-3}). *(2½ marks)*

  (d) (i) Draw a sketch graph showing the variation in pH of a solution when a 0.1 M aqueous sodium hydroxide is gradually added to 25.0 cm^3 of a 0.1 M aqueous ethanoic acid. *(02 marks)*

      (ii) Explain the shape of the graph which you have drawn in (d) (i).

(05 marks)

2. Complete each of the following reaction equations and in each case, outline a mechanism for the reaction.

  (a) $CH_3\,CO\,Cl\ +\ CH_3CH_2\,NH_2 \longrightarrow$ *(04 marks)*

  (b) $CH_2\,Cl\,CH_2\,Cl \xrightarrow[\text{heat}]{KOH_{(aq)}/CH_3CH_2OH}$ *(04 marks)*

  (c) $\underset{\text{(phenyl)}}{\bigcirc}\!\!-CH=CH_2\ +\ Br_2 \xrightarrow{CCl_4}$ *(03 marks)*

  (d) $CH_3\,COOH + CH_3\,OH \xrightarrow[\text{heat}]{\text{Conc. } H_2SO_4}$ *(5½ marks)*

  (e) $\bigcirc\ +\ \xrightarrow[\text{warm}]{\text{Fuming } H_2SO_4\,(aq)}$ *(3½ marks)*

3. Carbon, silicon, tin and lead are some of the elements in group IV of the Periodic Table.

   (a) (i) Write the formulae of the hydrides of the elements. (02 marks)

       (ii) Carbon can combine with hydrogen to form a wide variety of compounds, silicon forms fewer compounds with hydrogen while hydrogen compounds of lead and tin are very limited in number. Explain. (02 marks)

   (b) Discuss the reaction of the hydrides of the above elements with;

       (i) dilute hydrochloric acid. (2½ marks)
       (ii) sodium hydroxide. (02 marks)
       (iii) water. (02 marks)

   (c) Explain how;

       (i) chlorine reacts with tin and lead. (04 marks)
       (ii) nitric acid reacts with carbon and lead. (5½ marks)

4. (a) (i) Explain what is meant by the term **standard electrode potential**. (03 marks)

       (ii) State **three** factors that affect the value of electrode potential. (1½ marks)

   (b) With the aid of a labelled diagram, describe how a standard hydrogen electrode works. (06 marks)

   (c) Some half-cell reactions are shown below

   $$Fe^{2+}(aq) + 2e \rightarrow Fe(s); \ E^\theta = -0.41 \text{ V}.$$

   $$X^{2+}(aq) + 2e \rightarrow X(s); \ E^\theta = -0.76 \text{ V}.$$

   Write the;

       (i) cell notation for the overall cell. (01 mark)
       (ii) equation for the overall cell reaction. (1½ marks)

   (d) Calculate the e.m.f for the cell in (c) and predict whether the reaction is feasible or not. (03 marks)

   (e) A steady current of 12.0 A was required to electroplate a substance Q with 15.0 g of iron using iron(II) sulphate as electrolyte.
   Calculate the time taken for Q to be electroplated. ($1 F = 96,500$ C; $Fe = 56$). (03 marks)

   (f) State **two** industrial applications of electrolysis other than electroplating. (01 mark)

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5. (a) The boiling points and the atomic numbers of group VII elements in the Periodic Table are given in the Table **1**.

Table 1

Element	Flourine	Chlorine	Bromine	Iodine
Boiling point ($^\circ$C)	−188	−34.7	58.8	184.0
Atomic Number	9	17	35	53

(i) Draw a graph to show how the boiling points of the elements vary with atomic number. *(03 marks)*

(ii) Explain the shape of your graph. *(2½ marks)*

(b) Describe the reaction of group VII elements with sodium hydroxide. *(Your answer should include conditions and equations).* *(10 marks)*

(c) Explain how silver nitrate can be used to distinguish chloride, bromide and iodide ions. *(4½ marks)*

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

(i) lattice energy. *(01 mark)*
(ii) hydration energy. *(01 mark)*
(iii) enthalpy of solution. *(01 mark)*

(b) Describe an experiment that can be carried out to determine the enthalpy of solution of calcium iodide. *(08 marks)*

(c) Some thermochemical data are shown below:

Enthalpy of atomisation of iodine =   +106.8 kJ mol^{-1}.
First ionisation energy of calcium =   +590 kJ mol^{-1}.
Second ionisation energy of calcium = +1145 kJ mol^{-1}.
Enthalpy of atomisation of calcium =   +178.2 kJ mol^{-1}.
Enthalpy of formation of calcium iodide = −533.5 kJ mol^{-1}.
Electron affinity of iodine =   −295.4 kJ mol^{-1}.

(i) Draw an energy level diagram for the formation of calcium iodide and use it to calculate the lattice energy of calcium iodide. *(4½ marks)*

    (ii)   Calculate the enthalpy of solution of calcium iodide.   *(1½ marks)*
           (The hydration energies of calcium and iodide ions are −1562
           and −307 kJ mol^{-1} respectively).

    (iii)   Comment on the solubility of calcium iodide.   *(01 mark)*

  (d)   Explain the trend in the lattice energies of the halides of potassium.
        (The lattice energies of KF, KCl and KI are = −813, −710 and
        −643 kJ mol^{-1} respectively).   *(02 marks)*

7.   Describe how the following conversions can be effected.
    *(Equations are **not** required.)*

  (a)   *Ethanol* to *methanal.*   *(5½ marks)*

  (b)   Calcium carbide to *ethane–1, 2– diol.*   *(05 marks)*

  (c)   *Ethanol* to *methane.*   *(04 marks)*

  (d)   *Propanoic acid* to *propan–2–ol.*   *(5½ marks)*

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

  (a)   The boiling point of *propan–1–ol* is 98 °C, whereas butane with
        approximately the same formula mass boils at −0.5 °C.   *(2½ marks)*

  (b)   Concentrated sulphuric acid cannot be used to prepare hydrogen
        bromide from sodium bromide.   *(2½ marks)*

  (c)   The solubility of the hydroxides of elements in group II of the
        Periodic Table increases in the order;

        $Be(OH)_2$ < $Mg(OH)_2$ < $Ca(OH)_2$ < $Sr(OH)_2$ < $Ba(OH)_2$.
                    (3½ marks)

  (d)   Phenol is sparingly soluble in water but it is readily soluble in dilute
        sodium hydroxide.   *(04 marks)*

  (e)   The bond angles in water and ammonia molecules are 105° and 107°
        respectively.   *(3½ marks)*

  (f)   The first ionisation energy of magnesium is greater than that of
        aluminium. *(The atomic numbers of Mg and Al are 12 and 13 respectively).*
                    (04 marks)