THE UNITED REPUBLIC OF TANZANIA
NATIONAL EXAMINATIONS COUNCIL
ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

132/2 **CHEMISTRY 2**

(For Both School and Private Candidates)

Time: 2:30 Hours **Thursday, 16th February, 2012 a.m.**

Instructions

1. This paper consists of **twelve (12)** questions in sections A, B and C.
2. Answer **five (5)** questions by choosing at least **one (1)** question from each section.
3. Each question carries **twenty (20)** marks.
4. Mathematical tables and non-programmable calculators may be used.
5. Cellular phones are **not** allowed in the examination room.
6. Write your **Examination Number** on every page of your answer booklet(s).
7. For calculations you may use the following constants:

   Gas constant, R = 8.31 J mol^{-1} K^{-1} or 0.082 atm mol^{-1} K^{-1} dm^3
   GMV = 22.4 dm^3
   1 litre = 1dm^3 = 1000 cm^3
   1 faraday = 95,500 coulombs
   Velocity of light, c = 3.0 x 10^8 m/s
   Atomic masses: H = 1, C = 12, O = 16, Na = 23, Ca = 40.

SECTION A

1. (a) The calculated lattice energies for the ionic compounds $MgCl_2$ and the hypothetical ionic compound MgCl are -2502 and -753 kJ/mole, respectively. Given that the enthalpy of atomization of Mg = 146 kJ/mole, 1st ionization energy of Mg = 738 kJ/mole, 2nd ionization energy of Mg = 1450 kJ/mole, enthalpy of atomization of Cl_2 = 121 kJ/mole and electron affinity of chlorine = 364 kJ/mole, calculate the following:
   (i) Enthalpies of formation of MgCl and $MgCl_2$ and decide which of the two compounds is energetically stable.
   (ii) The enthalpy of decomposition of the hypothetical solid MgCl into Mg and $MgCl_2$.

(8 marks)

(b) A sample of 112.2 g of copper metal at 157.2 °C was introduced into an insulated vessel containing 247.5 cm^3 of glycerol ($C_3H_8O_{3(l)}$) at 38.8 °C. If the final temperature was 45.1 °C, calculate molar heat capacity of glycerol, given that the density of glycerol = 1.26 gcm^{-3} and specific heat capacity of copper = 0.393 $Jg^{-1}°C^{-1}$.

(4 marks)

(c) The heat of combustion of methane, carbon and hydrogen are 890.5 kJ/mole, 393.5 kJ/mole and 285.5 kJ/mole, respectively. The heat of sublimation of carbon is 720.0 kJ/mole and heat of dissociation of hydrogen molecule is 431.0 kJ/mole. Calculate the C – H bond energy in methane.

(8 marks)

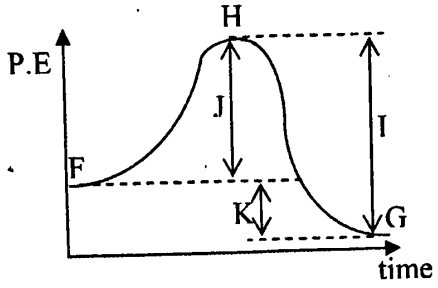
2. (a) The reaction between BrO_3^- and Br^- in aqueous acidic medium is given by the equation $BrO_3^-{}_{(aq)} + 5Br^-{}_{(aq)} + 6H^+{}_{(aq)} \rightarrow 3Br_2 + 3H_2O$. The following table gives the results of four different experiments.

Experiment number	**1**	**2**	**3**	**4**
$[BrO_3^-]$	0.20	0.40	0.40	0.20
$[Br^-]$	0.20	0.20	0.40	0.20
$[H^+]$	0.02	0.20	0.20	0.40
Initial rates $moldm^{-3}sec^{-1}$	1.28×10^{-2}	2.56×10^{-2}	5.12×10^{-2}	5.12×10^{-2}

Use the results in the table above to calculate the
(i) order of reaction with respect to each reactant.
(ii) value of the rate constant.

(8 marks)

(b) The following diagram represents the progress of one step reaction,
$N_2 + M_2 \rightarrow 2NM$.



(i) Predict whether the reaction is endothermic or exothermic by giving one reason.
(ii) What does each of the following letters F, G, H, I, J and K represent?
(6 marks)

(c) Determine K_c value for the reaction
$\frac{1}{2}N_{2(g)} + \frac{1}{2}O_{2(g)} + \frac{1}{2}Br_{2(g)} \rightleftharpoons NOBr_{(g)}$, given that, at 298 K
- $2NO_{(g)} \rightleftharpoons N_{2(g)} + O2_{(g)}$ $K_c = 2.4 \times 10^{30}$
- $NO_{(g)} + \frac{1}{2}Br_{(g)} \rightleftharpoons NOBr_{(g)}$ $K_c = 1.4$.

(6 marks)

3. (a) (i) With the aid of a well labelled diagram, describe how Daniel cell is used to supply electricity. **(7marks)**

(ii) Write equations for the reactions taking place at the electrodes and the overall equation at (a)(i).
(2 marks)

(b) (i) Calculate the e.m.f. of a cell operating under standard conditions given that:

	E^{θ}/V
$Cu^{2+}/Cu_{(s)}$	+ 0.34
$Zn^{2+}/Zn_{(s)}$	- 0.76
$Ag^{+}/Ag_{(s)}$	+ 0.799

(ii) Explain how the e.m.f. of the cell would be affected by increasing either $[Cu^{2+}]$ or $[Zn^{2+}]$.
(iii) If the $Zn^{2+}/Zn_{(s)}$ electrode system was replaced by $Ag^{+}/Ag_{(s)}$ electrode system, what would be the e.m.f. of the cell?
(11 marks)

4. (a) The dissociation constant K_a for the reaction
$HCO_3^- + H_2O \rightleftharpoons CO_3^{2-} + H_3O^+$ is 4.8×10^{12} m^2, calculate the pH of 0.02 M sodium bicarbonate solution.
(6 marks)

(b) A solution is initially 0.1 M Fe^{3+} and 0.1 M Zn^{2+}. From their solubility products, calculate the hydroxyl ion concentration needed to cause precipitation of each hydroxide. Which of the two hydroxides begins to precipitate? Give reasons. Given K_{sp} of $Fe(OH)_3 = 1.1 \times 10^{-36}$ mol^4dm^{-12} and K_{sp} of $Zn(OH)_2 = 1.8 \times 10^{-14}$ mol^3dm^{-9}.
(6 marks)

(c) Given K_{sp} of silver chromate is 9×10^{-12} mol^2 dm^{-6}, calculate the molar solubility of silver chromate in

(i) water

(ii) 0.1 M potassium dichromate.

(8 marks)

SECTION B

5. Explain each of the following phenomena and give balanced chemical equation where necessary.

(a) Nitrogen dioxide is paramagnetic but not dinitrogen tetraoxide.

(2.5 marks)

(b) Silicon tetrachloride reacts vigorously with water, but carbon tetrachloride does not react with water.

(2.5 marks)

(c) $HClO_4$ is a stronger acid than HNO_3.

(2.5 marks)

(d) Boron hydroxide is more acidic than aluminium hydroxide.

(2.5 marks)

(e) Aqueous solution of aluminium chloride is acidic while that of sodium acetate is basic.

(2.5 marks)

(f) When magnesium metal is introduced into a beaker containing ammonium chloride solution hydrogen gas evolved.

(2.5 marks)

(g) Action of concentrated sulphuric acid on calcium phosphate.

(2.5 marks)

(h) Reaction of orange coloured potassium dichromate with hydrogen chloride.

(2.5 marks)

6. (a) Briefly explain the following terms

(i) Interstitial hydrides.

(ii) Clathrates.

(iii) inert pair effect.

(iv) rusting of iron.

(12 marks)

(b) A complex compound of cobalt named sulphatopentammine cobalt (III) bromine can form two ionisation isomers.

(i) Give the formula and names of the isomers.

(ii) Explain how you can distinguish the two isomers.

(8 marks)

7. With the aid of balanced chemical equations, explain the following observations:

(a) (i) In aqueous solution, copper (II) ions are blue but turn green when excess hydrochloric acid is added to it.

(ii) The addition of aqueous alkali to aqueous solution of iron (III) ions, give gelatinous reddish brown precipitate.

(iii) Anhydrous magnesium chloride ($MgCl_2$) can not be obtained by heating the hydrated magnesium chloride ($MgCl_2.6H_2O$).

(iv) The addition of aqueous ammonia solution to the solution of nickel (II) ions, gives green precipitate which dissolves to form blue solution when excess ammonia is added.

(10 marks)

(b) Account for the following chemical phenomena:

(i) Some lithium compounds are covalent while compounds of other elements in the same group are electrovalent.

(ii) The first ionization energy of magnesium is comparatively higher than that of aluminium even though magnesium is more electropositive than aluminium.

(iii) Potassium manganate (VII) is not used as a primary reagent in volumetric analysis as potassium dichromate (VI) does.

(iv) Concentrated nitric acid has no practical reaction with iron.

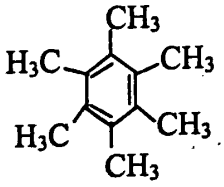
(10 marks)

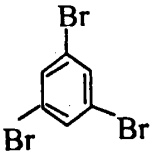
8. Describe essential steps during extraction of aluminium. Show clearly the reaction equations during the process.

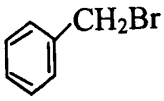
(20 marks)

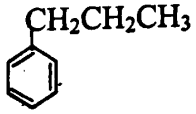
SECTION C

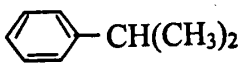
9. (a) Name the following compounds:

(i) 

(ii) 

(iii) 

(iv) 

(v) 

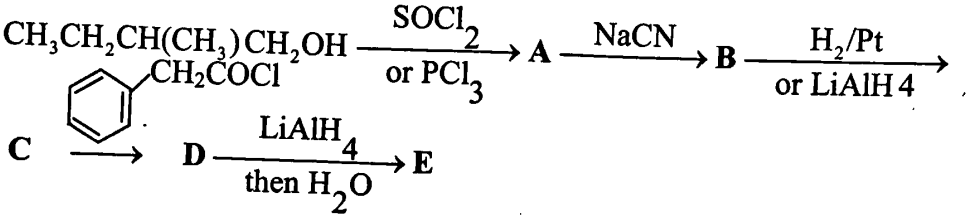
(5 marks)

(b) When benzene is first nitrated, and that product is chlorinated, the product is different from when the order of carrying out the two mono-substitution reaction is reversed (i.e chlorination then nitration). Explain this by using equations.

(5 marks)

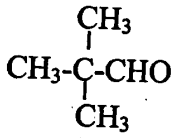
(c) Using benzene or toluene as the only aromatic organic starting material, device syntheses for the following:
(i) m – bromonitrobenzene
(ii) p – nitroethylbenzene
(iii) p – bromobenzoic acid
(iv) p – toluenesulforic acid.

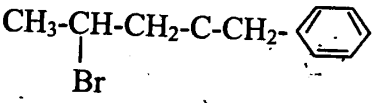
10. (a) Write the structures of compounds A to E in the following synthetic sequence: **(9 marks)**

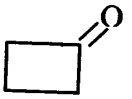


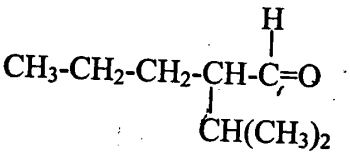
(7.5 marks)

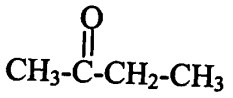
(b) Name the following structures by using the IUPAC rules:

(i) 

(ii) 

(iii) 

(iv) 

(v) 

(5 marks)

(c) Write the structural formulae and IUPAC names of four isomers of the compound with molecular formula $C_5H_{10}O_2$.

11. (a) Distinguish between **(7.5 marks)**
(i) inductive effect and mesomeric effect.
(ii) activating group and deactivating group.

(4 marks)

(b) An aromatic derivative of benzene **M** is composed of 80% carbon, 6.66% hydrogen and 13.33% oxygen. **M** has molecular mass of 120 and it does not respond to silver mirror test.

(i) Find empirical and molecular formula of **M**.
(ii) Write the molecular structure of **M**.

(6 marks)

(c) Write the structures of the products obtained when **M**
(i) reacts with iodine in the presence of alkali.
(ii) reacts with hydrogen cyanide followed by lithium aluminium hydride in dry ether.
(iii) reacts with chlorine in the presence of ferric chloride.
(iv) dimerises.

(10 marks)

12. (a) Briefly explain the following terms:
(i) Green manure.
(ii) Farm yard manure.
(iii) Compost manure.
(iv) Organic fertilizers.
(v) Artificial fertilizers.

(5 marks)

(b) The exchangeable hydrogen from 5.0 g of oven dry soil was neutralized with 10 cm^3 of 0.1 M NaOH. If the total c.e.c. of the soil was 25 meq/100g of soil, calculate the
(i) percentage of base saturation of the soil sample.
(ii) concentration of the H^+ ions in (meq) in 75 g of the oven dry soil.

(6 marks)

(c) Comment on the nature of the soil at (b)(i) above.

(3 marks)

(d) A soil sample of 20 g was analysed and found to contain 0.0015 g of Ca. What is the concentration of calcium in the soil in milliequivalent per 100 g of soil?

(6 marks)