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

132/1 **CHEMISTRY 1**

(For Both School and Private Candidates)

Time: 3 Hours **Thursday, 04th May, 2017 a.m.**

Instructions

1. This paper consists of **fourteen (14)** questions in sections A, B and C.
2. Answer **four (4)** questions from section A and **three (3)** questions from each of sections B and C.
3. Each question carries **ten (10)** 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:
   - Rydberg constant $R_H = 1.09678 \times 10^7\ m^{-1}$
   - Gas constant, $R = 8.31\ Jmol^{-1}\ K^{-1}$ or $0.0821\ atm\ mol^{-1}\ K^{-1}\ dm^3$
   - $GMV = 22.4\ dm^3$
   - Standard temperature = 273 K
   - Standard pressure = 760 mmHg
   - Planck's constant, $h = 6.63 \times 10^{-34}\ Js$
   - Velocity of light, $c = 3.0 \times 10^8\ m/s$
   - Mass of an electron $= 9.11 \times 10^{-31}\ kg$.

SECTION A (40 Marks)

Answer **four (4)** questions from this section.

1. (a) Distinguish between the following:
   (i) Isotopes and isotopy.
   (ii) Azimuthal quantum number and magnetic quantum number. **(3 marks)**
   (iii) Atomic mass unit and relative atomic mass.

   (b) The mass spectrographic measurements of an element X whose atomic number is 31 indicated peaks at 79.21, 11.2 and 9.59. The isotopic masses are 69, 70 and 71 atomic mass unit (a.m.u) respectively. **(1.5 marks)**
   (i) Write the conventional symbols for the three isotopes. **(3 marks)**
   (ii) Calculate the relative atomic mass of X. **(1 mark)**
   (iii) Explain why atomic weights of elements are not whole numbers.

   (c) The mass number of two atoms, A and B with the same atomic number are 235 and 238 respectively. If A contains 143 neutrons in its nucleus, find the number of neutrons and electrons in B. **(1.5 marks)**

2. (a) Define the following:
   (i) Dative bonding.
   (ii) Ionic bonding.
   (iii) Valence electrons. **(1.5 marks)**

   (b) Summarise three major ideas of the Valence Shell Electron Pair Repulsion (VSEPR) theory. **(1.5 marks)**

   (c) Outline four differences between sigma and pi bonds. **(4 marks)**

   (d) Determine the name of a geometrical structure and one example of the molecule formed from the following hybridized orbitals.
   (i) Sp^3.
   (ii) Sp^2.
   (iii) Sp. **(3 marks)**

3. (a) (i) Write two similarities between diffusion and effusion. **(1 mark)**
   (ii) The rate of effusion of unknown gas was measured to be 24.0 mL/min. Under the same conditions, the measured rate of effusion of pure methane was 47.8 mL/min. What is the molar mass of the unknown gas? **(3 marks)**

   (b) Using the kinetic theory of gases, state four properties of an ideal gas. **(2 marks)**

   (c) A sample of ammonia gas with a volume of 3.5 dm^3 at a pressure of 1.68 atm was compressed to a volume of 1.35 dm^3 at constant temperature.
   (i) Calculate the final pressure of the gas. **(3 marks)**
   (ii) Name and state the governing gas law in question 3(c)(i). **(1 mark)**

4. (a) Define the following:
   (i) Relative density of a gas.
   (ii) Normal density of a gas. **(1 mark)**

   (b) Show that the relative molecular mass of a gas is twice its relative vapour density. **(3 marks)**

   (c) (i) A determination of the density of ethanoic acid vapour at 1 atm pressure and 400 K gave a result of 2.74 g/dm^3. Assuming ideal condition, calculate the apparent molecular weight of ethanoic acid under these conditions.
   (ii) What can you deduce from your results in 4(c)(i)? Briefly explain. **(3.5 marks)**

   (d) A 0.0721 g of water vaporised at 150 °C and 755 mmHg pressure occupied a volume of 140 cm^3. Show that the relative molecular mass of water vapour proves the formula for steam. **(2.5 marks)**

5. (a) (i) Give the meaning of osmotic pressure of a solution. **(1 mark)**
   (ii) Briefly explain in terms of vapour pressure why the freezing point of a solution is lower than that of a pure solvent. **(1 mark)**

   (b) When water and ice are mixed, the temperature of the mixture is 0 °C, but, if methanol (CH_3OH) and ice are mixed, a temperature of +10 °C is readily attained. Explain why the two mixtures show such different temperature behaviours. **(2 marks)**

   (c) Calculate the molar mass of Y given that a solution of 60 g of Y in 1 dm^3 of water exerts an osmotic pressure of 4.31 x10^5 Nm^{-2} at 25 °C. **(2.5 marks)**

   (d) A 0.003 kg of acetic acid (CH_3COOH) is added to 500 cm^3 of water. If 23% of the acid is dissociated, what will be the depression in freezing point? (K_f for water = 1.86 °Ckg/mol, density of water = 0.997 g/cm^3). **(3.5 marks)**

6. (a) (i) Define vapour pressure. **(0.5 mark)**
   (ii) Using Raoult's law of vapour pressure, show that the lowering of vapour pressure is proportional to the mole fraction of the solute. **(2 marks)**

   (b) Briefly explain why the solution becomes ideal when it is made more dilute. **(2 marks)**

   (c) Two liquids A and B form an ideal solution when mixed. At 298 K, the vapour pressure of pure A and B for a mixture of 1 mole of A and 3 moles of B are 32 kPa and 16 kPa, respectively. Calculate;
   (i) the vapour pressure of the mixture. **(3 marks)**
   (ii) the mole fraction of A in the vapour which is in equilibrium with the mixture. **(2.5 marks)**

SECTION B (30 Marks)

Answer **three (3)** questions from this section.

7. (a) (i) Briefly explain the principle of solvent extraction. **(3 marks)**
   (ii) Compare and contrast fractional distillation from steam distillation. **(3 marks)**

(b) Steam distillation of a mixture of an organic compound B and water at 98 °C and pressure of 101320 Pa yielded a distillate containing 31.6% by volume of B. The vapour pressure of pure water at this temperature is 94260 Pa. The densities of B and water are 0.961 g/cm^3 and 1.000 g/cm^3, respectively. Calculate the relative molecular mass of B. **(4 marks)**

8. (a) Define the following:
   (i) Standard enthalpy change of neutralization.
   (ii) Heat of solution.
   (iii) Bond energy. **(2 marks)**
   (iv) Standard enthalpy change of combustion.

   (b) Differentiate between:
   (i) Lattice energy and energy of reaction.
   (ii) Standard molar enthalpy change of dissolution and heat of combustion. **(2 marks)**

   (c) Given the standard enthalpy change of combustion of hydrogen, ΔH^o = -286 kJ/mol; carbon, ΔH^o = -394 kJ/mol; methane, ΔH^o = -890 kJ/mol; Ethane, ΔH^o = -1390 kJ/mol and heat of formation of CH_3CH_3OH is -276 kJ/mol, calculate in kJ/mol the enthalpy change;
   (i) of formation of methane. **(1.5 marks)**
   (ii) of formation of ethene. **(1.5 marks)**
   (iii) for the reaction $CH_2{=}CH_2(g) + H_2O(g) \rightarrow CH_3CH_2OH(g)$ **(1.5 marks)**
   (iv) of combustion of 4.48 dm^3 of ethane. **(1.5 marks)**

9. (a) Study carefully the information in the following table and then answer the questions that follow.

Process	ΔH°_{298K} (kJ mol^{-1})
$Na(s) \rightarrow Na(g)$	+108
$\frac{1}{2}Cl_2(g) \rightarrow Cl(g)$	+121
$Na(g) \rightarrow Na^+(g) + e^-$	+496
$Cl(g) + e^- \rightarrow Cl^-(g)$	-349
$NaCl(s) \rightarrow Na^+(g) + Cl^-(g)$	+787
$NaCl(s) + H_2O(l) \rightarrow Na^+(aq) + Cl^-(aq)$	+4.0

   (i) Calculate the enthalpy change for the process $2Cl(g) \rightarrow Cl_2(g)$.
   (ii) Calculate the standard molar enthalpy change for the process: **(1 mark)**
   $Na(s) + \frac{1}{2}Cl_2(g) \rightarrow Na^+(g) + Cl^-(g)$.
   (iii) Compare the different between enthalpy change for the processes: $NaCl(s) \rightarrow Na^+(g) + Cl^-(g)$ and $NaCl(s) + H_2O(l) \rightarrow Na^+(aq) + Cl^-(aq)$, and then comment on the differences. **(1.5 marks)** **(0.5 mark)**

(b) Magnesium will displace copper from copper (II) sulphate solution according to the equation:
$CuSO_4(aq) + Mg(s) \longrightarrow Cu(s) + MgSO_4(aq)$.
When an excess of magnesium was added to 100 cm^3 of 0.1 mol dm^{-3} copper(II) sulphate, the temperature increased by 46.3 °C. It is known that density and specific heat capacity of the solution are 1.0 g cm^{-3} and 4.18 J g^{-1} $°C^{-1}$, respectively. Calculate:

(i) The molar enthalpy change for the reaction. **(4 marks)**
(ii) Minimum quantity of magnesium required. **(2 marks)**
(iii) The change in temperature if only 0.8 g magnesium was added. **(1 mark)**

10. (a) Differentiate between the following:

(i) Equilibrium constant, K_c, and rate constant, K.
(ii) Equilibrium position and rate of reaction. **(2 marks)**

(b) Consider the following reversible equilibrium:
$2C_2H_6(g) + 7O_2(g) \rightleftharpoons 4CO_2(g) + 6H_2O(l)$

(i) Write down the K_c and K_p expressions. **(1 mark)**
(ii) Derive the relationship between K_c and K_p. **(3 marks)**

(c) A 7.52 cm^3 of a gas H was mixed with 7.0 cm^3 of a gas Q in a one litre flask at 298 K. At equilibrium, 10.93 cm^3 of gas HQ was formed. Calculate the equilibrium constant, K_c for the reaction:
$H_2(g) + Q_2(g) \rightleftharpoons 2HQ(g)$ **(4 marks)**

SECTION C (30 Marks)

Answer **three (3)** questions from this section.

11. (a) Using one appropriate example in each case, briefly explain the meaning of the following terms:

(i) Homologous series.
(ii) Functional group.
(iii) Unsaturated hydrocarbon.
(iv) Alkyl group. **(4 marks)**

(b) Write the formula of the following alkyl groups:

(i) Methyl group.
(ii) Butyl group.
(iii) Ethyl group.
(iv) Propyl. **(2 marks)**

(c) Complete the following reactions:

(i) $CaC_2\,(s) + 2H_2O\,(l) \xrightarrow[\text{cold}]{}$

(ii) $CH_3CH_2OH \xrightarrow[\text{Heat}]{\text{Conc.}H_2SO_4}$

(iii) $CH_3CH_2Cl + KOH \xrightarrow[\text{Heat}]{\text{Alcohol}}$

(iv) $CH_3CH{=}CH_2 + H_2O \xrightarrow{H^+}$ **(4 marks)**

12. (a) Define the following terms:
    (i) Resonance energy.
    (ii) Aromatic compound. **(2 marks)**

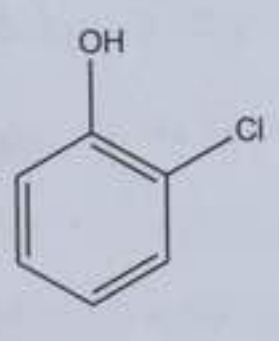
(b) Briefly explain why methyl benzene (toluene) is more reactive than benzene. **(1 mark)**

(c) Write equations to show what will happen when methyl benzene is
    (i) treated with chloromethane (CH_3Cl) in presence of aluminium chloride ($AlCl_3$).
    (ii) treated with chlorine in presence of ultraviolet (uv) light.
    (iii) refluxed with potassium manganate (VII) ($KMnO_4$) in the presence of an acid.
    (iv) burnt in excess oxygen. **(4 marks)**

(d) Indicate in the following aromatic compounds, which substituent group entered first. Give reason(s) for your answer.

(i)

(ii)



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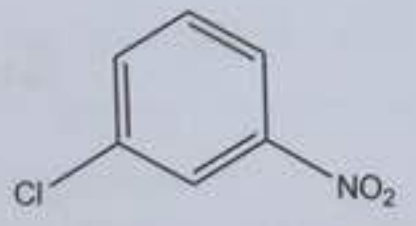


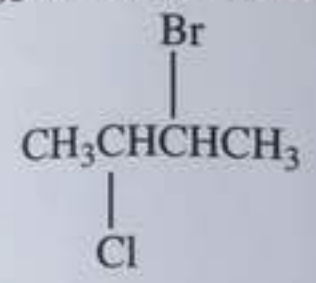
(3 marks)

13. (a) Briefly explain why alkyl chlorides are not friendly to the environment. **(1 mark)**

(b) Write the structures of the following alkyl halides:
    (i) 2-chloro-3-methylpentane.
    (ii) Pent-2-ene.

(1 mark)

(c) Give IUPAC names of the following compounds:

(i) 

(ii) $ClCH_2C{\equiv}CCH_2Br$

(iii) $CHF_2CBrClF$

(iv) $CCl_3CHClCCl_3$

(4 marks)

(d) A primary alkyl halide, A, (C_4H_9Br) reacted with alcoholic KOH to give compound B. Compound B reacted with HBr to give C which is an isomer of A. When C (in ether solution) reacted with Na metal, it gave compound D (C_8H_{18}).

(i) Give the structure of A. **(1 mark)**

(ii) Write equations for all the reactions. **(3 marks)**

14. (a) State Markovnikoff's rule. **(1 mark)**

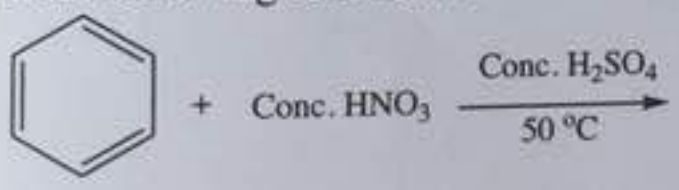
(b) By indicating whether the reaction will involve side chain, aromatic ring or both, write chemical equations showing the reaction between phenylethene (styrene) and:

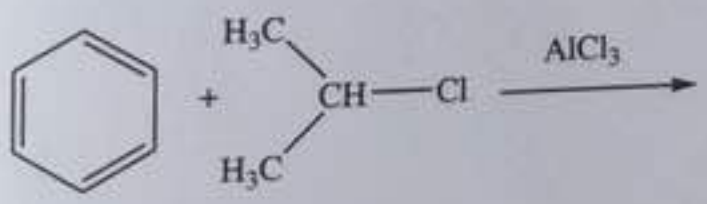
(i) Br_2.

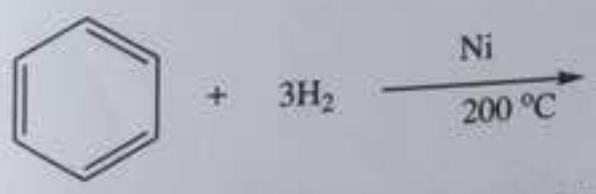
(ii) H_2, (Pt) at 25°C.

(iii) H_2, (Pt) at 200 °C. **(3 marks)**

(c) Complete the following reactions:

(i) 

(ii) 

(iii) 

(3 marks)

(d) Arrange the following set of compounds in order of decreasing relative reactivity to an electrophile E^+:

(i) chlorobenzene, 2,4-dinitrobenzene, 4-nitrochlorobenzene.

(ii) methylbenzene, 4-nitromethylbenzene, 2,4-dinitromethylbenzene. **(3 marks)**