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, 08th May, 2014 p.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).

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 $0.082\ atm\ mol^{-1}\ K^{-1}\ dm^3$
- $GMV = 22.4\ dm^3$
- Standard temperature = 273 K
- Standard pressure = 760 mmHg
- Planck constant, $h = 6.63 \times 10^{-34}\ Js$
- Velocity of light, $c = 3.0 \times 10^8\ m/s$
- Mass of electron $= 9.11 \times 10^{-31}\ kg$
- Atomic mass: P = 31, Cl = 35.5.

SECTION A (40 marks)

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

1. (a) Nitrogen and oxygen combine endothermically at elevated temperature according to the equation $2N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{2(g)}$. If the equilibrium constant for the reaction is 4.3×10^{-3} at 3000 °C and 1 atm, calculate the composition of each in the equilibrium if 2 moles of each nitrogen and oxygen were heated. **(6 marks)**

(b) When 20.85 g of PCl_5 was heated in a sealed tube of 4 dm^3 volume, the pressure in the vessel was found to be 1.5 atm. At this pressure it was found that PCl_5 dissociated to 80%. Calculate the partial pressure of each gas. **(4 marks)**

2. (a) State the following laws:
   (i) Graham's law of gas diffusion
   (ii) Charles' law
   (iii) Boyle's law. **(3 marks)**

(b) Identify two laws in 2(a) above and show how they can be combined to give a single gas equation. **(2 marks)**

(c) A chloride of phosphorus is found to diffuse in the gaseous state more slowly by a factor of 2.216 than nitrogen under the same conditions.
   (i) Calculate the relative molecular mass of chloride.
   (ii) Given that chloride molecule contains one atom of phosphorus, write down its formula. **(5 marks)**

3. (a) Define colligative properties and give four examples of those properties. **(3 marks)**

(b) Nicotine which is extracted from tobacco leaves is completely immiscible with water at temperature below 60 °C.
   (i) What is the molality of nicotine in an aqueous solution that starts to freeze at - 0.45 °C given that $K_f = 1.86\ °Cm^{-1}$?
   (ii) If this solution is obtained by dissolving 1.921 g of nicotine in 48.92 g of water, what must be the molar mass of nicotine?
   (iii) Combustion analysis shows that, nicotine consists of 74.03% C; 8.70% H and 17.27% N by mass. What is the molecular formula of nicotine? **(7 marks)**

4. (a) (i) Write the atomic number of an atom with electronic configuration of $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$.
   (ii) X occurs naturally as ^{37}X and ^{35}X. Given that the relative atomic mass of X is 35.5, determine the percentage of ^{35}X and ^{37}X in the sample of element X. **(3 marks)**

(b) "The motion of the electron in an atom is not a simple rotation around an orbit, but rather a three dimensional standing wave which obeys Schrödinger equation".
   (i) In which atomic model is this statement based?
   (ii) Name other two atomic models that attempt to explain the structure of the atom. **(2 marks)**

(c) (i) Describe the dual nature of electromagnetic radiation and wave particle duality.
   (ii) Calculate the velocity of an electron whose wavelength is 10^{-9} metres. **(5 marks)**

5. (a) (i) Arrange the following coloured lights in order of increasing wavelength:
green, blue, red, violet and yellow.

(ii) With reference to a prism spectrometer, briefly explain the term frequency of a line.
(2 marks)

(b) (i) With reference to krypton at ground state, how many electrons have the following set of quantum numbers?
$n = 3$;
$n = 3, l = 2$;
$ml = 0$;
$n = 2, l = 1, ml = -1, s = ½$. **(4 marks)**

(ii) Briefly explain in molecular orbital terms, the bonding in silane (SiH_4). **(4 marks)**

6. (a) A solution is prepared from 90 g of water and 10.6 g of a non-volatile, non-dissociating solute. The vapour pressure of the solution at 60°C is found to be 18.91×10^3 Nm^{-2}. Calculate the approximate molecular mass of the solute given that, the vapour pressure of water at 60°C is 19.92 Nm^{-2}.
(4 marks)

(b) Ethanol and water form an azeotropic mixture which boils at 78.1 °C with 95.6 % ethanol. The boiling points of pure ethanol and water are 78.4 °C and 100 °C respectively.
(i) Draw a temperature – mole fraction phase diagram of ethanol-water solution.
(ii) What happens when a solution of less than 50% ethanol is boiled? **(6 marks)**

SECTION B (30 marks)

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

7. (a) Calculate the standard heat of formation of the reaction $C_{(graphite)} + 2H_{2(g)} \rightarrow CH_{4(g)}$ from the following sets of data:

(i) $CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(l)}$ $\Delta H^\circ = -890$ kJ mol^{-1}
(ii) $C_{(graphite)} + O_{2(g)} \rightarrow CO_{2(g)}$ $\Delta H^\circ = -394$ kJ mol^{-1}
(iii) $H_{2(g)} + ½O_{2(g)} \rightarrow H_2O_{(l)}$ $\Delta H^\circ = -286$ kJ mol^{-1}. **(6 marks)**

(b) $NaCl_{(s)}$ can be formed directly from sodium and chlorine elements via the reaction;
$Na_{(s)} + ½Cl_{2(g)} \rightarrow NaCl_{(s)}$, $\Delta H^\circ f = -411$ kJ mol^{-1}.
Construct a well labeled Born-Haber cycle for the formation of $NaCl_{(s)}$. **(4 marks)**

8. (a) For the equilibrium: $2NO_{(g)} + O_{2(g)} \rightleftharpoons 2NO_{2(g)}$ $\Delta H^\circ = -115$ kJ (left→right) established in a closed vessel at a fixed temperature, the equilibrium constant reaction has a value of 15 mol^{-1} l.
(i) Write an expression for the equilibrium constant K.
(ii) What does the magnitude of K indicate?
(iii) What will be the effect on the value of the equilibrium constant K if the temperature is increased? Give reason for your answer.
(iv) Calculate the equilibrium concentration of NO_2 when the equilibrium concentrations of NO and O_2 are both 0.1 mol l^{-1}. **(6 marks)**

(b) The value for equilibrium constant, K, for the following reaction equation is equal to 1
acid + alcohol $\rightleftharpoons$ ester + water.

(i) Predict the maximum yield of ester under the given value of K, and give reason why this yield might not be achieved in practice.
(ii) Will the addition of a catalyst increase the yield of ester? Give reason.
(iii) Comment on the statement that, "increasing the concentration of the alcohol in the reaction mixture would increase the yield of ester by altering the value of K". **(4 marks)**

9. (a) State four postulates of the kinetic theory of gases. **(4 marks)**

(b) Define root mean square speed of gas molecules. **(2 marks)**

(c) The root mean square speed of hydrogen molecules at a fixed temperature is 1600 m/s. What is the root mean square speed of oxygen molecules at the same temperature? **(4 marks)**

10. (a) Giving reason; explain for each of the following observations:
(i) The boiling points of water, ethanol and ethoxyethane are in the reverse order of their relative molecular masses unlike those of their analogous sulphur compounds; H_2S, C_2H_5SH and $C_2H_5SC_2H_5$.
(ii) BF_3 is non-polar but NF_3 is polar.
(iii) Aluminuim flouride has much higher melting point than aluminium chloride. **(6 marks)**

(b) Given that X, Y, and Z represent elements of atomic numbers 9, 19 and 34,
(i) write the electronic configuration of X, Y and Z.
(ii) predict the type of bonding which you would expect between X and Y; Y and Z.
(iii) predict giving reasons for relative volatility, electrical conductance and solubility in water of the compounds formed between X and Y compaired to that formed between X and Z. **(4 marks)**

SECTION C (30 marks)

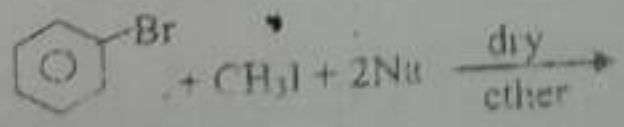
Answer **three (3)** questions from this section.

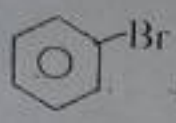
11. (a) Briefly explain the following:
(i) Chain reaction.
(ii) Chain initiating step.
(iii) Chain propagation step.
(iv) Chain terminating step. **(4 marks)**

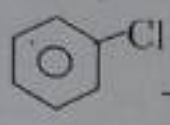
(b) (i) Why benzene molecule shows extra stability?
(ii) What is resonance and how is it applicable in benzene? **(3 marks)**

(c) Suggest suitable chemical tests to distinguish between the following:
(i) Hexane and 2-hexene.
(ii) Propyne and propene.
(iii) 1-pentyne and 2-pentyne. **(3 marks)**

12. (a) Give the organic product in each of the following:

(i) 

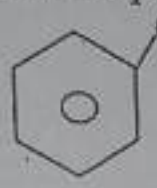
(ii)  $+ 3H_2 \xrightarrow[200^oC]{Pt}$

(iii)  $\xrightarrow[360^oC,\ 150\ atm.]{Aq.NaOH}$ Then dil.HCl

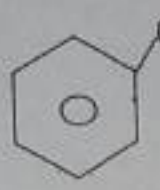
(3 marks)

(b) Show the mechanism for the nitration of benzene. **(3 marks)**

(c) With the help of chemical equations show how you can prepare the following:

(i)  from C_6H_6

(ii) $CH_3CH_2CH_2CH_3$ from CH_3CH_3

(iii)  from $CH \equiv CH$

(Iv) $CH_3CH_2CH_2CH_2CH_3$ from $CH_3CH_2CCCH_3$ **(4 marks)**

13. (a) Briefly explain why $(CH_3)_3CBr$ reacts by S_N^1 mechanism while CH_3CH_2Br reacts by mechanism. **(3 marks)**

(b) The ease for the nucleophilic substitution reaction of alkyl halide R-X with OH is the o C-I > C-Br > C-Cl > C-F. Explain this trend. **(3 marks)**

(c) Give all possible isomers of the compound $C_5H_{10}Br_2$ and their corresponding IUPAC names. **(4 marks)**

14. (a) What is ozonolysis? **(1 mark)**

(b) A hydrocarbon having a molar mass of 96 $gmol^{-1}$ and molecular formula C_7H_{12} was ozonol and then hydrolysed in the presence of zinc. The products of ozonolysis were ethanal, propa and glyoxal (H-C-C-H). Determine the structure of the hydrocarbon and show ozonolysis o compound. **(3 marks)**

(c) Two isomeric hydrocarbons P and Q have molecular formula C_9H_{12}. On oxidation, P g monocarboxylic acid, when treated with soda lime yields benzene. Q is oxidized to tricarboxylic acid and can undergo nitration reaction to give two mono-nitro derivatives.

(i) Write down the structural formula of P and Q.

(ii) Write an equation to show how Q is oxidized to give tricarboxylic acid.

(iii) Name the compound which is formed when P undergoes oxidation. **(6 marks)**