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

132/1

CHEMISTRY 1
(For Both School and Private Candidates)

Time: 3 Hours **Year : 2021**

Instructions

1. This paper consists of sections A and B with a total of **ten (10)** questions.
2. Answer **all** questions in section A and **two (2)** questions from section B.
3. Each question carries **ten (10)** marks in section A and **fifteen (15)** marks in section B.
4. Mathematical tables and non-programmable calculators may be used.
5. Cellular phones and any unauthorised materials 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:
   - Rydberg constant, $R_H = 1.09678 \times 10^7\ m^{-1}$
   - Gas constant, $R = 8.31\ Jmol^{-1}\ K^{-1}$ or $0.0821\ atmmol^{-1}\ K^{-1}\ dm^3$
   - GMV = $22.4\ dm^3$
   - 1 litre = $1000\ cm^3 = 1\ dm^3$
   - Standard temperature = 273 K
   - Standard pressure = 760 mmHg = $1.0 \times 10^5\ NM^{-2}$ = 1 atm
   - 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 = 9.11×10^{-31} kg
   - Atomic masses: H = 1, C = 12, N = 14, O = 16, Cl = 35.5, K = 39, S = 32

SECTION A (70 Marks)

Answer **all** the questions in this section.

1. (a) Differentiate the following terms:
   (i) Isotopy from isotopes. **(1 mark)**
   (ii) Atomic spectrum from photon. **(1 mark)**
   (iii) Continuous spectrum from line spectrum. **(1 mark)**

   (b) Calculate the frequency of a wave in a visible region formed following the emission of energy by an electron falling from energy level n = 4 to the ground level. **(5 marks)**

   (c) List two uses of mass spectrometer. **(2 marks)**

2. (a) Identify a more energetically stable compound among the following pairs:
   (i) $NaBr$ and $NaBr_2$
   (ii) ClO_4 and ClO_4^-
   (iii) OF_4 and SeF_4
   (iv) SO_4 and XeO_4 **(4 marks)**

   (b) Although the Valency Shell Electron Pair Repulsion theory (VSEPR) predicts correctly the CH_4 and NH_3 molecular geometries (or shapes), it does not account for the differences in (H-C-H) and (H-N-H) bonds whose angles are 109.5^o and 107.3^o, respectively. Give reasons for the deviations. **(4 marks)**

   (c) Giving a reason, classify the type of bond involved in each of the following chemical equations:

   (i) $Ca: + 2\cdot\ddot{\underset{\cdot\cdot}{Cl}}: \longrightarrow [Ca]^{2\oplus}(:[\ddot{\underset{\cdot\cdot}{Cl}}:]^{\ominus})_2$

   (ii) $H^{\oplus} + \cdot\ddot{\underset{\cdot\cdot}{F}}: \longrightarrow H:\ddot{\underset{\cdot\cdot}{F}}:$

   (2 marks)

3. (a) Calculate the partial vapour pressure of water in a mixture of 36 g of water and 32 g of methanol at 298 K, if the vapour pressure of pure water at 298 K is 3.2 kPa. **(4 marks)**

   (b) A candle wax is approximately a non-volatile organic compound with molecular formula $C_{22}H_{46}$ and soluble in carbon tetrachloride. Calculate the vapour pressure of a solution made by dissolving 10 g of the wax in 40 g of carbon tetrachloride at 23 °C, if the carbon tetrachloride has a vapour pressure of 100 mmHg at 23 °C. **(4 marks)**

   (c) Comment on the observation that, further dilution of 0.1 M KCl solution causes the observed relative molecular mass to approach the theoretical value 37.3. **(2 marks)**

4. (a) Using the following chemical equations and values provided for each, calculate the enthalpy of formation of $Ca(OH)_2$.
   $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l) \quad \Delta H = -68.3\,kCal$

$Ca(s) + H_2O(l) \rightarrow Ca(OH)_2(s)$ $\Delta H = -15.3 kCal$

$Ca(s) + \frac{1}{2}O(g) \rightarrow CaO(s)$ $\Delta H = -151.8 kCal$ **(5 marks)**

(b) Diborane, (B_2H_6) is synthesized in the laboratory according to the equation:

$$2B(s) + 3H_2(g) \longrightarrow B_2H_6(g).$$

Calculate the heat change for the synthesis of diborane from its elements, using the enthalpies provided in the following table:

S/N	Reaction	ΔH kJ
1	$2B(s) + \frac{3}{2}O_2(g) \rightarrow B_2O_3(s)$	- 1273
2	$B_2H_6(g) + 3O_2(g) \rightarrow B_2O_3(s) + 3H_2O(g)$	- 2035
3	$H_2(g) + \frac{1}{2}O_2(g) \rightarrow 3H_2O(l)$	- 286
4	$H_2O(g) \rightarrow H_2O(l)$	44

(5 marks)

5. (a) Justify on the following facts:
   (i) Ion exchange in the soil system is a reversible process.
   (ii) All calcium or magnesium compounds can be used as liming materials.
   (iii) Aluminium contributes to soil acidity. **(6 marks)**

   (b) Rungwe high school farm soil requires 100 kg of nitrogen to fulfill the plant requirement of nitrogen per hectare. If the farm has 60 hectares, calculate the number of bags of ammonium sulphate, $(NH_4)_2SO_4$ fertilizer required to meet this demand. (One bag of fertilizer weighs 25 kg). **(4 marks)**

6. (a) When dilute hydrochloric acid is added to a yellow solution of potassium chromate, an orange solution of dichromate is produced. Briefly, explain what would be observed as a result of:
   (i) adding more hydrochloric acid.
   (ii) adding dilute sodium hydroxide solution.
   (iii) adding anhydrous calcium chloride. **(6 marks)**

   (b) Briefly explain the following:
   (i) Hydrogen gas is evolved when magnesium is introduced into a beaker containing aqueous solution of ammonium chloride.
   (ii) $AlCl_3$ reacts chemically with water while NaCl does not. **(4 marks)**

7. (a) (i) What are the two properties that makes organic compounds suitable source of fuel? **(2 marks)**

   (ii) Compressed natural gas methane, (CH_4) is a fossil fuel found in large quantitities in our country, Tanzania. Due to its several advantages, compressed natural gas is considered the most promising vehicles' fuel and thus it should be promoted as the main fuel in our country. State four benefits offered by the compressed natural gas over conventional fuel like gasoline and diesel. **(4 marks)**

(b) Suggest suitable chemical test to distinguish between the following compounds:
(i) Butane and 1-butene.
(ii) Propyne and propene.
(iii) Pent-1-yne and pent-2-yne.
(iv) Propane and 1-bromo propane. **(4 marks)**

SECTION B (30 Marks)

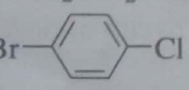
Answer **two (2)** questions from this section.

8. (a) (i) State Le Chatelier's principle. **(1 mark)**
(ii) How does homogeneous equilibrium differ from heterogeneous equilibrium as applied in Chemistry? **(1 mark)**

(b) Predict the direction of the net reaction for each of the following equilibrium reactions when the pressure of the system is doubled at constant temperature. Give one reason for each case.
(i) $2Pb(s) + 3O_2(g) \rightleftharpoons 2PbO(s) + 2O_2(g)$ **(1 mark)**
(ii) $PCl_5(g) \rightleftharpoons PCl_3(s) + Cl_2(g)$ **(1 mark)**
(iii) $H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g)$ **(1 mark)**

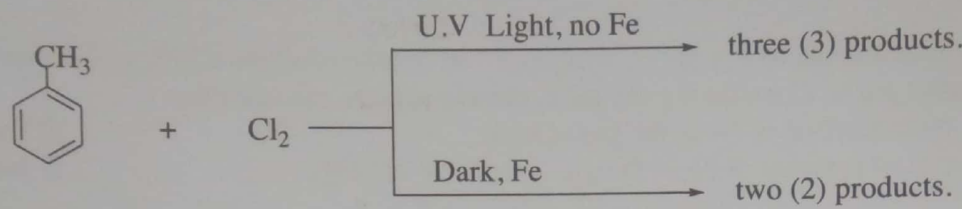
(c) Hydrogen iodide gas was synthesized from hydrogen gas and iodine vapour at 450°C in a 2.0 litres vessel. The value of the equilibrium constant, Kc for the reaction was found to be 50.5. If 1.0×10^{-2} moles of hydrogen gas, 3.0×10^{-2} moles of iodine vapour and 2.0×10^{-2} moles of hydrogen iodide were placed in a vessel at the stated temperature;
(i) write a balanced equilibrium reaction equation for the synthesis of hydrogen iodide gas. **(1 mark)**
(ii) calculate the reaction quotient (Q) for the reaction. **(3 marks)**
(iii) state whether the reaction will proceed to the right or left of the equation. Give a reason. **(2 marks)**
(iv) with a reason, comment on a possible effect regarding the equilibrium position, if the pressure of the reaction system is increased. **(1 mark)**

(d) Consider the reaction; $K_2 + N_2 \rightleftharpoons 2KN$ $\Delta H = -20\,J\,mol^{-1}$ which has an equilibrium constant, Kc = 10 at 25°C. Calculate the equilibrium constant in terms of partial pressure, (Kp) at the same temperature. **(3 marks)**

9. (a) Write the IUPAC name of the following organic compounds:
(i) CCl_3CH_3
(ii) $CHCl_2CCl_2CHCl_2$
(iii) 
(iv) $CCl_3CH_2CCl_3$ **(2 marks)**

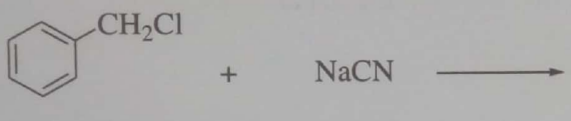
(b) With the aid of a chemical equation (no reaction mechanisms is needed), give a reason for the position occupied by bromide atom when bromine reacts with:
(i) phenol. **(1 mark)**
(ii) benzene carbaldehyde. **(1 mark)**

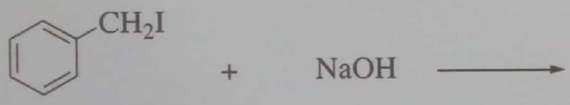
(c) Write the structures and the names of five products in the following reaction:



(5 marks)

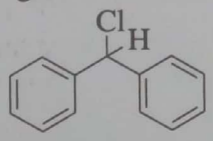
(d) Write the product of each of the following nucleophilic substitution reactions:

(i) 

(ii) 

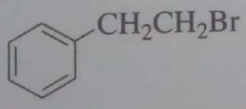
(2 marks)

(e) Write a chemical test to distinguish the following chemical compounds.

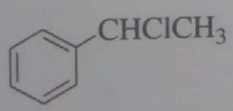
(i) Bromobenzene from 

(ii) Vinyl bromide from *p*-chlorobenzene. **(2 marks)**

(f) Using chemical equations, show step-wise conversion of 2-phenol into each of the following organic compounds:

(i) 

(1 mark)

(ii) 

(1 mark)

10. (a) Show how Boyle's law and Charle's law are special cases of the ideal gas law. **(3 marks)**

(b) (i) Theoretically, ideal gasses cooled to a temperature of -273.15 ^{o}C will occupy zero (0) volume. With reason(s) comment on whether gases practically occupy zero volume at such temperature. **(2 marks)**

(ii) Molecule A is twice as heavy as molecule B. Which of these has higher kinetic energy at any temperature? Give a reason. **(1 mark)**

(c) Briefly explain the following:
(i) Liquid ammonia bottle is cooled before opening the seal.
(ii) The tyre of an automobile is inflated to a slightly lower pressure in summer than in winter. **(2 marks)**

(d) A 1.0 litre sample of dry air at 25 °C and 786 mmHg contains 0.925 g of nitrogen gas (N_2) and other gases. Considering dry air to behave ideally, calculate the:
(i) mole fraction of N_2 in the gas sample. **(3 marks)**
(ii) partial pressure of N_2 in the gas sample (in mmHg). **(1 mark)**

(e) The volume of 200 cm^3 of oxygen gas required 250 seconds to diffuse through a porous membrane. Under the identical conditions, 200 cm^3 of gas 'Z' diffused in 177 seconds. Calculate the relative molecular mass of gas 'Z'. **(3 marks)**