

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

132/1

CHEMISTRY I
(For Both School and Private Candidates)

Time: 3 Hours

Thursday, 05th May 2016 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).
7. For calculations you may use the following constants:
 - Rydberg constant $R_H = 1.09678 \times 10^7 \text{ m}^{-1}$
 - Gas constant, $R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$ or $0.0821 \text{ atm mol}^{-1} \text{ K}^{-1} \text{ dm}^3$
 - GMV = 22.4 dm^3
 - Standard temperature = 273 K
 - Standard pressure = 760 mmHg
 - Planck's constant, $h = 6.63 \times 10^{-34} \text{ Js}$
 - Velocity of light, $c = 3.0 \times 10^8 \text{ m/s}$
 - Mass of an electron = $9.11 \times 10^{-31} \text{ kg}$.

SECTION A (40 Marks)

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

1. (a) State the following:
 - (i) Postulates of Bohr's atomic model. (4 marks)
 - (ii) Shortcomings of the Bohr's atomic model. (3 marks)
- (b) An electromagnetic radiation of wavelength $2420 \text{ \AA}$ is sufficient to ionize the sodium. Calculate the ionization energy of sodium atom in kJ mol^{-1} . (3 marks)
- (c) Calculate the wave number of the longest wavelength transition in Balmer series of hydrogen. (3 marks)

2. (a) Define the following:
 - (i) principal quantum number (2 marks)
 - (ii) azimuthal quantum number. (3 marks)
- (b) Given the quantum number, $n = 3$. Answer the following questions:
 - (i) List all possible orbitals present in this quantum energy.
 - (ii) Write possible values of m_l and m_s for this quantum number. (3 marks)
- (c) The mass spectrum of an element enables the relative abundance of each isotope of the element to be determined. Data relating to mass spectrum of an element X whose atomic number is 35 is as indicated in the table below. Study the data and answer the questions that follows:

Mass Number of Isotopes	Relative Abundance
79	50.5%
81	49.5%

- (i) Define the term isotope.
 - (ii) Write the conventional symbols for the two isotopes of element X.
 - (iii) Calculate the relative atomic mass of X to three significant figures. (5 marks)
3. (a) Give reasons for the following observations:
 - (i) Both sodium and hydrogen occur in group IA of the periodic table, yet the melting point of sodium chloride is 800°C while that of HCl is -114°C .
 - (ii) Sodium chloride is soluble in water but not in benzene.
 - (iii) Although both oxygen and sulphur are in the same group of the periodic table, the boiling point of oxygen (H_2O) is a liquid but the hydride of sulphur (H_2S) is a gas at room temperature. (3 marks)
- (b) (i) Study the following compounds: hydrogen sulphide (H_2S), ammonia (NH_3), hydrogen fluoride (HF), chloroform (CHCl_3) and ethanoic acid (CH_3COOH). With reasons, describe the compounds which contain and those which do not contain hydrogen bonding.
- (ii) Briefly explain why dimethyl ether is more volatile than ethanol although their molecular weights are the same. (7 marks)
4. (a) State why was it necessary to modify the ideal gas equation and show how the modified equation looks like. Define all symbols in the equation. (4 marks)

- (b) Briefly explain why beyond certain temperatures gases cannot be liquefied. (2 marks)
- (c) One mole of diethyl ether occupies 1.5 litres at 227 °C. Calculate the pressure if the Van der Waals constants for diethyl ether are: $a = 17.38 \text{ atm.litre}^2 \text{ mol}^{-1}$ and $b = 0.134 \text{ litre mol}^{-1}$. (4 marks)
5. (a) Define the following terms with reference to gases:
 (i) critical temperature
 (ii) critical volume
 (iii) critical pressure. (3 marks)
- (b) From ideal gas equation, derive the relationship between density of a gas in grams per dm^3 , the gas pressure in atmospheres, the temperature (T) in kelvin, the relative molecular mass of a gas (M_r) and the gas constant, R. (3 marks)
- (c) A certain dry gas is composed of 21% by volume of oxygen, 1% of argon and 78% of nitrogen. Find its density in g dm^{-3} at 20 °C and 98.65 kNm^{-2} pressure. (4 marks)
6. (a) Give two differences between osmosis and diffusion. (2 marks)
- (b) When 15 g of glucose ($\text{C}_6\text{H}_{12}\text{O}_6$) was dissolved in 50 g of a certain solvent with a relative molecular mass of 180 g, the freezing point was depressed by 8.0 °C. Using these data, calculate the freezing point depression constant, for the solvent. (2 marks)
- (c) An aqueous solution of sugar containing 19.15 g of sugar per dm^3 has osmotic pressure of $136,300 \text{ Nm}^{-2}$ at 20 °C. Calculate the relative molecular mass of sugar. (6 marks)

SECTION B (30 Marks)

Answer three (3) questions from this section.

7. (a) Give a brief molecular explanation of positive and negative deviations from Raoult's law for non-ideal binary solutions. (2 marks)
- (b) What vapour pressure lowering difference(s), if any, would you expect for 1 M aqueous solutions of (i) CaCl_2 , (ii) KBr and (iii) Na_3PO_4 ? Justify your answer. (3 marks)
- (c) Benzene (C_6H_6) and toluene ($\text{C}_6\text{H}_5\text{CH}_3$) form an ideal solution. At 333 K, the vapour pressure of pure benzene is 53.3 kPa while that of pure toluene is 26.7 kPa. If a solution is prepared by mixing two moles of benzene and three moles of toluene;
 (i) find the partial pressure of each component in the vapour phase in equilibrium with this solution at 333.
 (ii) calculate the total vapour pressure of the solution.
 (iii) explain which substance will be collected from the top of the distillation column, if a mixture of benzene and toluene is distilled. (5 marks)

8. (a) Pure ethanol, (C_2H_5OH) boils at $78.3^\circ C$ and at pressure of 760 mmHg. When 2.51 g of an organic compound M (Mwt = 146 g) is dissolved in 100 g of ethanol, the solution boils at $85.9^\circ C$ and 760 mmHg.
- Explain why the boiling point of ethanol was raised.
 - Calculate the molal boiling point, K_b for ethanol. (5 marks)
- (b) A solution was prepared by dissolving 2.40 g of biphenyl ($C_{12}H_{10}$) in 75.00 g of benzene. Calculate the boiling point of the solution given that $K_b = 2.53^\circ C/m$; $K_f = 5.12^\circ C/m$; boiling point of pure benzene = $80.1^\circ C$ and freezing point of pure benzene is $5.5^\circ C$. (5 marks)
9. (a) (i) Briefly explain the dynamic nature of equilibrium reaction.
- Use hydrogen (H_2) and iodine (I_2) gases which produce hydrogen iodide (HI) gas to illustrate the point mentioned in (a)(i). (5 marks)
- (b) (i) Mention the four common stresses explained by Le Chatelier's principle to help maximize the yield of ammonia gas in the Haber process.
- The equation for production of ammonia gas is as follows;

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)} \quad \Delta H^\circ = -92.6 \text{ kJ}$$
 From the given equation, explain the maximum yield of ammonia can be achieved. (5 marks)
10. (a) State the following:
- Heat of reaction
 - Exothermic reaction
 - Endothermic reaction. (3 marks)
- (b) 1.5 g of ammonium nitrate (NH_4NO_3) was added to 35.0 g of water in a plastic beaker and stirred until the salt dissolved. The temperature of the solution dropped from $22.7^\circ C$ to $19.4^\circ C$. Based on the given information respond to the following questions:
- Is the process endothermic or exothermic? Explain.
 - Calculate the heat of solution of NH_4NO_3 in kJ/mol., given that specific heat capacity of water = $4.184 \text{ J/g}^\circ C$. (7 marks)

SECTION C (30 Marks)

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

11. (a) Briefly explain the following terms and give an example of family of organic compounds in each case:
- hydrocarbon
 - saturated hydrocarbon
 - unsaturated hydrocarbon. (3 marks)
- (b) 10 cm^3 of a gaseous hydrocarbon Q required 45 cm^3 of oxygen for complete combustion. Q reacts with 1 mole of bromine gas to form a brominated compound of relative molecular mass of 344 which contains 79.2% bromine.
- Determine the molecular formula of Q.
 - Give the structural formula of Q. (7 marks)

2 (a) Define the following:

- (i) isomers
- (ii) isomerism.

(2 marks)

(b) Write the structural formulae of the following:

- (i) 3-methyl-1 pentene
- (ii) 2-methyl-2-pentene
- (iii) 2,2-dimethyl pentane
- (iv) 4-methyl pent-2-yne.

(4 marks)

(c) Identify a simple chemical test that can be used to distinguish between the following compounds.

- (i) 1-butyne and 2-butyne
- (ii) Butane and butene.

(4 marks)

3 (a) (i) • Outline the stages in the formation of chloromethane from methane and chlorine at 450°C.

(ii) • Give reason why the chloromethane obtained in (a) (i) is not pure.

(5 marks)

(b) Bromoalkanes may react with alcoholic potassium hydroxide solution to form alkenes. Basing on this statement answer the following questions:

- (i) What type of organic reaction is this reaction?
- (ii) Write an equation for the reaction of 1-bromobutane with alcoholic potassium hydroxide. Show all mechanisms involved.
- (iii) Draw the structural formula of the alkene obtained by reaction between 2-bromobutane and alcoholic potassium hydroxide.

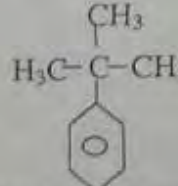
(5 marks)

(a) Briefly explain the following:

- (i) The C-C bonds are all equal and intermediate in length between a single and a double bond in benzene.
- (ii) Dry ether is necessary in the preparation and use of the Grignard reagent.

(7 marks)

(b) The chlorination of methyl benzene and 1,1-dimethylethyl benzene yield the following isomers:

	2	3	4
	60%	0.5%	39.5%
	22%	8%	70%

Study the isomers and then explain the observed different product ratio.

(3 marks)