

**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)

Year: 2022

Time: 3 Hours

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 unauthorized 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, $R_H = 1.09678 \times 10^7 \text{ m}^{-1}$
 - Gas constant, $R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$ or $0.0821 \text{ atm mol}^{-1} \text{ K}^{-1} \text{ dm}^3$
 - Gram Molar Volume (GMV) $= 22.4 \text{ dm}^3 = 22400 \text{ cm}^3$
 - Standard temperature $= 273 \text{ K}$
 - Standard pressure $= 760 \text{ mm Hg} = 1.0 \times 10^5 \text{ N m}^{-2} = 1 \text{ atm}$
 - Planck's constant, $h = 6.63 \times 10^{-34} \text{ J s}$
 - Velocity of light, $c = 3.0 \times 10^8 \text{ m/s}$
 - Mass of an electron $= 9.11 \times 10^{-31} \text{ kg}$
 - Atomic masses: $\text{H} = 1, \text{C} = 12, \text{O} = 16, \text{S} = 32$

SECTION A (70 Marks)

Answer **all** questions in this section.

1. (a) Energy of an electron in hydrogen atom is given by the expression

$$E_n = \frac{-1.312 \times 10^6}{n^2} \text{ J/mol.}$$

- (i) Calculate the amount of energy required to promote an electron from the first energy level to the third energy level.
- (ii) Why an electron in its ground state possesses energy less than zero? **(03 marks)**
- (b) (i) The elements **X**, **Y** and **Z** have the following electronic configurations:
X: $1s^2 2s^2 2p^6 3s^2 3p^6$
Y: $1s^2 2s^2 2p^6 3s^2$
Z: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

The first ionization energies of the three elements (not in the same order) are 420, 740, and 1500 kJ/mol and the atomic radii are 1.60, 0.94 and 1.97 Å. Identify the three elements and match the appropriate ionization energy and atomic radius to each configuration. **(03 marks)**

- (ii) Excited sodium atoms may emit radiation with the frequency of 5.09×10^{14} /s. What is the energy of the photons associated with this radiation? **(02 marks)**

- (c) Briefly, differentiate the following terms:
- (i) Line from continuous spectrum.
- (ii) Absorption from emission spectrum. **(02 marks)**

2. (a) Consider the following reaction that takes place in a fixed volume of a container:
 $\text{H}_2(\text{g}) + \text{Br}_2(\text{g}) \rightarrow 2\text{HBr}(\text{g}) \quad \Delta H^\circ = -104 \text{ kJ/mol.}$ How each of the changes affect the quantity of the reactants, products and equilibrium constant (K_C)? Answer by writing "Increase", "Decrease", or "No change" appropriately, in a tabular form:

Change	H_2	Br_2	HBr	K_C Value
Addition of some H_2				
Removal of some HBr				
Raise in temperature				
Increase in pressure				

(08 marks)

- (b) When the reaction $2\text{NO}(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow 2\text{NOCl}(\text{g})$ was studied at 25°C, the partial pressures at equilibrium were found to be 1.2 atm for NOCl , 5.0×10^{-2} atm for NO and

0.3 atm for Cl. What would be the K_p value for this reaction at 25 °C?

(02 marks)

3. (a) If the vapour pressure of water at 20 °C is 17.5 mm Hg and lowering of vapour pressure of a sugar solution is 0.061 mm Hg, calculate;
- The relative lowering of vapour pressure.
 - The vapour pressure of the solution.
 - The mole fraction of sugar and water.

(04 marks)

- (b) Ethanoic acid had a freezing point of 16.63 °C. When 2.5 g of an organic solute was added to 40 g of the acid, the freezing point was lowered to 14.48 °C. Calculate the relative molecular mass of the solute (Given K_f for ethanoic acid = 3.9 °C/m).

(03 marks)

- (c) An aqueous solution freezes at 272.07 K while pure water freezes at 273 K. Calculate the molality and boiling point of this solution (Given K_f for water = 1.86 K/m, K_b = 0.512 K/m).

(03 marks)

4. (a) (i) Predict whether a chemical bond will be covalent or ionic basing on the charge and the relative size of the cations and anions as follows:

Cation/anion	Ionic radius (nm)	Chemical bond
C^{4+}	0.015	
I^-	0.216	
Na^+	0.095	
F^-	0.136	

- (ii) "Intermolecular hydrogen bonding and dative covalent bonding are among the types of bonds exhibited by a number of molecules." Justify this statement by drawing a structure of a molecule for each type of the bonds aforementioned.

(04 marks)

- (b) Briefly, comment on the following observations:

- Fluorine, chlorine and bromine form hydrides, but the hydride of fluorine forms hydrogen bond, whereas those of chlorine and bromine do not.
- When molecules of hydrogen chloride are placed together, they do not show induced dipole interactions but they do so when placed with molecules of argon.

(02 marks)

- (c) (i) What is the difference between sp^2 and sp hybridization?
- (ii) Which bond is stronger than the other in each of the following pairs? Give a reason for your choice.

$C \equiv O$ or $C=O$; $C-N$ or $C-O$; $C-C$ or $C=C$

(04 marks)

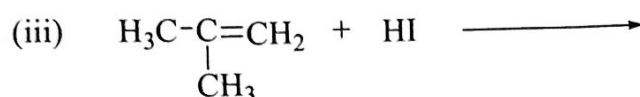
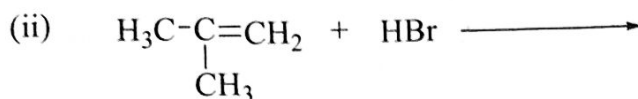
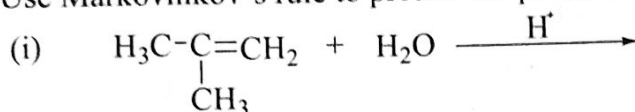
5. (a) A certain chemical industry in Tanzania got an order to supply some reagents for research purposes. However, the requested reagents were not in the stock at that moment though enough starting materials shown in each case were present. What synthetic route(s) will you devise in each case to meet the order required? Confine your reactions in not more than four steps.

- Propan – 1, 2-diol from propene
- Acetone from 2-methyl propene

- (iii) Ethanol from propane
- (iv) Ethyne from calcium carbide

(05 marks)

(b) Use Markovnikov's rule to predict the products of the following reactions:



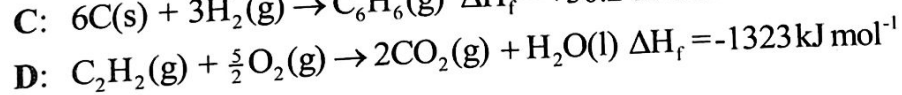
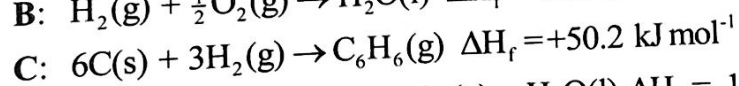
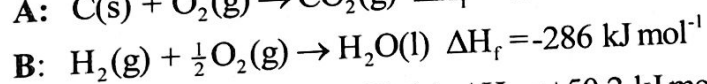
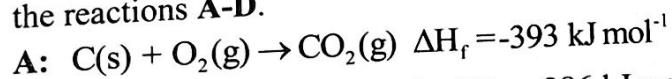
(03 marks)

(c) "Wurtz synthesis is not suitable for preparation of an asymmetrical alkane." Briefly, justify this statement while supporting your answer with a chemical equation. **(02 marks)**

6. (a) (i) Given that, the heat of formation of $\text{CO}_2(\text{g})$, $\text{CO}(\text{g})$ and $\text{H}_2\text{O}(\text{g})$ are -393.5 , -121.31 and -241.8 kJ/mol, respectively. Calculate the enthalpy change (ΔH°) for the reaction $\text{CO}_2(\text{g}) + \text{H}_2(\text{g}) \longrightarrow \text{CO}(\text{g}) + \text{H}_2\text{O}(\text{g})$. **(04 marks)**

(ii) What are the four factors affecting the quantity of heat evolved or absorbed during a physical or chemical transformation? **(02 marks)**

(b) Determine the heat of formation of ethyne basing on the following information given by the reactions A-D.



(04 marks)

7. (a) Suppose you are employed by the National Environment Management Council (NEMC), an institution which has a mandate to oversee the environmental management issue in Tanzania; What are the four possible intervention measures of environmental degradation you can address to the community. **(04 marks)**

(b) "Most of the greenhouse gases are produced from anthropogenic activities." Justify this statement by giving two reasons while supporting your answer with appropriate chemical equation in each case. **(02 marks)**

(c) Acid rain is formed as a result of excessive dissolution of gases in the atmosphere to produce acids with pH less than 5.6. What are the four chemical reactions that take place during the formation of an acidic rain? **(04 marks)**

SECTION B (30 Marks)

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

8. (a) (i) While pumping air into a ball, the volume as well as the pressure increase. Does the Boyle's law applicable here? Briefly, explain.
(ii) Hot air balloons are being used in the Serengeti National Park by tourists. Why hot air is more preferred in filling these balloons than cold air? Briefly, explain.
(iii) It is said that "Dalton's law of partial pressure cannot hold true for a mixture of SO_2 and O_2 gases. Briefly, explain the truth of this argument.
(iv) What would have happened to the gas pressure if the molecular collisions were not elastic? **(04 marks)**
- (b) The density of a gas at 27°C and 1520 mmHg pressure was found to be $5.46 \times 10^{-3} \text{ g/cm}^3$. What will be its density in g/dm^3 at **s.t.p.**? **(04 marks)**
- (c) (i) Relative densities of carbon dioxide and oxygen are 22 and 16, respectively. If 25 cm^3 of carbon dioxide diffuses in 75 seconds, what volume of oxygen gas will diffuse in 96 seconds under similar conditions? **(05 marks)**
(ii) What are the two significances of Graham's law of diffusion in our daily life? **(02 marks)**
9. (a) Briefly, explain five uses of metal oxides in daily life. **(05 marks)**
- (b) When a dilute nitric acid was added to a green solid **P**, a blue solution **Q** was formed and a gas **R** that formed a white precipitate with lime water was evolved. When the blue solution was evaporated to dryness by heating it in a crucible, a black solid **S**, brown fumes of gas **T** and a gas that relighted a glowing splint were formed.
(i) Identify solids **P** and **S**, and gases **R** and **T**.
(ii) Write an equation for the reaction between solid **P** and dilute nitric acid. **(06 marks)**
- (c) What is the importance of the following metal compounds in everyday life?
(i) Lime stone
(ii) Plaster of Paris **(04 marks)**
10. (a) Briefly explain the following concepts:
(i) Concentrated sulphuric acid is necessary for nitration of benzene.
(ii) Bromination of benzene takes place in the presence of Lewis acid, while that of hydroxybenzene does not require the presence of Lewis acid.
(iii) Despite chlorine atom being an electron withdrawing group, it directs an incoming group to the ortho or para positions in electrophilic aromatic substitution reactions. **(03 marks)**
- (b) During one of the practical sessions in a school, a student wanted to differentiate a set of reagents. Briefly, advise the student on how to differentiate the given sets of reagents while supporting your answer with a chemical equation:
(i) Benzene and ethane

- (ii) 3-chloro-2-methylpent-2-ene and 1-chloropropane
(iii) Bromobenzene and bromomethane (06 marks)
- (c) Briefly explain the following concepts:
- (i) $(\text{CH}_3)_2\text{CHBr}$ undergoes SN_1 mechanism, while $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$ undergoes SN_2 mechanism when they react with aqueous alkalis.
- (ii) Haloalkanes undergo nucleophilic substitution reactions, while halobenzenes undergo electrophilic substitution reactions. (04 marks)
- (d) Two isomeric hydrocarbons **K** and **L** have the molecular formula C_9H_{12} . On oxidation, **K** gives a monocarboxylic acid which when heated with excess soda lime yields benzene. When **L** is oxidized, it gives tricarboxylic acid, which can undergo nitration to give a mono-derivative. What are the structural formulae of **K** and **L**? (02 marks)