

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

ANSWERS

Year: 2013

Instructions

1. This paper consists of sections A, B and C with total of fourteen questions
2. Each question carries ten marks.

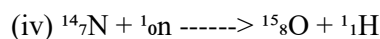
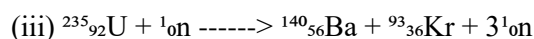
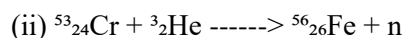
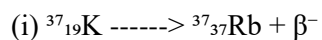
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1. (a) Differentiate nuclear reaction from chemical reaction.

- A nuclear reaction involves changes in the nucleus of an atom, leading to the transformation of elements and emission of radiation.
- A chemical reaction involves the rearrangement of electrons in atoms, without changing the atomic nuclei.

(b) Complete the following nuclear equations:



(c) The following figure shows the mass spectrum of lead. The highest peaks and the mass numbers of the isotopes are shown. Calculate the average atomic mass of lead.

$$\begin{aligned}\text{Average atomic mass} &= (204 \times 1.5 + 206 \times 22.6 + 207 \times 23.6 + 208 \times 52.3) / (1.5 + 22.6 + 23.6 + 52.3) \\ &= (306 + 4655.6 + 4895.2 + 10878.4) / 100 \\ &= 207.2 \text{ g/mol}\end{aligned}$$

2. (a) Lyman discovered a series of spectral lines for hydrogen in the ultraviolet region of the electromagnetic spectrum. What value must n_x have for this series? Give a reason for your answer.

$n_x = 1$, because the Lyman series corresponds to electronic transitions where electrons fall to the first energy level ($n = 1$).

(b) Calculate the energy of a line in the Lyman series with $n_1 = 1$ and $n_2 = \infty$.

$$\begin{aligned}\text{Using } \Delta E &= 2.18 \times 10^{-18} \text{ J } (1/n_1^2 - 1/n_2^2) \\ &= 2.18 \times 10^{-18} \text{ J } (1/1^2 - 1/\infty^2) \\ &= 2.18 \times 10^{-18} \text{ J}\end{aligned}$$

(c) An experimental iodine laser emits light of wavelength $1.315 \mu\text{m}$. Calculate the frequency of this light and the energy per photon.

$$\nu = c/\lambda$$

$$= (3.0 \times 10^8 \text{ m/s}) / (1.315 \times 10^{-6} \text{ m})$$

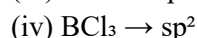
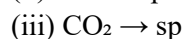
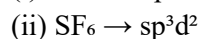
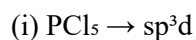
$$= 2.28 \times 10^{14} \text{ Hz}$$

Energy per photon, $E = h\nu$

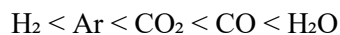
$$= (6.626 \times 10^{-34} \text{ J}\cdot\text{s}) \times (2.28 \times 10^{14} \text{ Hz})$$

$$= 1.51 \times 10^{-19} \text{ J}$$

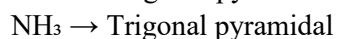
3. (a) Predict the hybridization of the following:



4. (a) Arrange the following substances in order of increasing melting points: CO_2 , H_2O , CO , H_2 , and Ar .



(b) Use VSEPR theory to predict the molecular geometry of the species:



(c) State two characteristics of compounds which are suitable for steam distillation.

- Must have appreciable volatility with steam.
- Should not decompose at boiling temperature.

5. (a) An aromatic compound Z was steam distilled at 98.6°C and 1 atm pressure. The distillate contained 25.5 g of water and 7.4 g of aromatic compound Z.

Given that the saturated vapour pressure of water at 98.6°C is 720 mmHg, calculate the relative molecular mass of the aromatic compound.

$$\text{Moles of water} = 25.5 / 18 = 1.417 \text{ mol}$$

Since pressure is proportional to moles,

$$\text{Moles of Z} = (7.4 / M_Z)$$

$$\text{Ratio of moles} = 720 \text{ mmHg} / 1 \text{ atm}$$

Solving for M_Z , we get:

$$M_Z = 132 \text{ g/mol}$$

(b) Benzene (C_6H_6) and toluene ($C_6H_5CH_3$) form a nearly ideal solution. At 313 K, the vapour pressure of pure benzene is 150 mmHg and that of pure toluene is 50 mmHg. Calculate the vapour pressure of a mixture of these two liquids containing equal masses at the given temperature.

$$\text{Moles of benzene} = (1 / 78)$$

$$\text{Moles of toluene} = (1 / 92)$$

$$\text{Mole fraction of benzene, } X_B = (1/78) / [(1/78) + (1/92)]$$

$$\text{Mole fraction of toluene, } X_T = 1 - X_B$$

$$\text{Total vapour pressure} = X_B \times P_B + X_T \times P_T$$

$$= 0.541 \times 150 + 0.459 \times 50$$

$$= 81.15 + 22.95$$

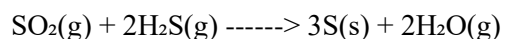
$$= 104.1 \text{ mmHg}$$

6. (a) Define the following:

(i) Molar volume of a gas at STP: The volume occupied by one mole of an ideal gas at standard temperature and pressure (22.4 L).

(ii) Dalton's law of partial pressures: The total pressure of a gas mixture is equal to the sum of the partial pressures of each gas.

(b) Two gas burettes, one containing 10 cm³ of SO₂ and the other containing 30 cm³ of H₂S, are separated by a stopcock. When the stopcock is opened, the gases react according to:



(i) Limiting reagent: H₂S (completely consumed).

(ii) Final pressure = (20 cm³ of excess SO₂) × (1 atm / 40 cm³)

= 0.5 atm

7. (a) Three elements F, G, and H have atomic numbers 17, 18, and 19 respectively.

(i) Electronic configurations:

F = $1s^2 2s^2 2p^6 3s^2 3p^5$

G = $1s^2 2s^2 2p^6 3s^2 3p^6$

H = $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

(ii) Type of ions:

F = Anion (Cl^-)

G = No ion (Noble gas)

H = Cation (K^+)

(iii) Periodic table placement:

F = Period 3, Group 17

G = Period 3, Group 18

H = Period 4, Group 1

(b) Study the hypothetical periodic table and answer the following:

(i) Most electronegative element: D

(ii) Pair of elements likely to form the strongest electrovalent bond: A and D

(iii) Two elements likely to have strongest reducing properties: A and F

(iv) Two elements which form neither negative nor positive ions: E and G

7. (a)

(i) Electronic configurations:

F (17) $\rightarrow 1s^2 2s^2 2p^6 3s^2 3p^5$

G (18) $\rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6$

H (19) $\rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

(ii) Type of ions formed:

F \rightarrow Anion (Cl^-)

G \rightarrow No ion (Noble gas)

H \rightarrow Cation (K^+)

(iii) Group and period placement:

F \rightarrow Group 17, Period 3

G \rightarrow Group 18, Period 3

H \rightarrow Group 1, Period 4

- (b) (i) Most electronegative element \rightarrow D
- (ii) Strongest electrovalent bond \rightarrow A and D
- (iii) Strongest reducing properties \rightarrow A and F
- (iv) Elements forming neither negative nor positive ions \rightarrow E and G

8. (a) (i) Diagonal relationship \rightarrow Similarity in properties of elements placed diagonally in the periodic table due to comparable charge-to-radius ratio. Example: Li and Mg.
 (ii) Anomalous behaviour \rightarrow Deviations from expected periodic trends due to small size, high ionization energy, or strong hydrogen bonding. Example: Fluorine in Group 17.

(b) Hydrides of Period 3 elements react with water differently:

- NaH reacts violently forming NaOH and H_2 .
- MgH_2 reacts slowly forming $Mg(OH)_2$.
- AlH_3 decomposes in water releasing H_2 .

(c) Arrange the oxides in order:

- (i) Increasing basic character: $SiO_2 < P_2O_5 < Al_2O_3 < MgO < Na_2O$
- (ii) Decreasing ionic character: $Na_2O > MgO > Al_2O_3 > P_2O_5 > SiO_2$

9. (a)

- (i) First ionization energy removes the outermost electron; second ionization removes an electron from an already positively charged ion.
- (ii) The second ionization energy of sodium is much higher than the first because removing an electron from a stable noble gas configuration (Na^+) requires significantly more energy.

(b) Sodium reactions:

- (i) $2Na + C_2H_5OH \rightarrow 2C_2H_5ONa + H_2$
- (ii) $2Na + 2NH_3 \rightarrow 2NaNH_2 + H_2$
- (iii) $2Na + O_2 \rightarrow Na_2O_2$
- (iv) $2Na + 2H_2O \rightarrow 2NaOH + H_2$

10. (a) Law of mass action: The rate of a reaction is proportional to the product of the concentrations of the reactants raised to their stoichiometric coefficients.

(b)



10% dissociation means 0.1 mole PCl_5 decomposes from 1 mole.

Total moles at equilibrium = $1 - 0.1 + 0.1 + 0.1 = 1.1$

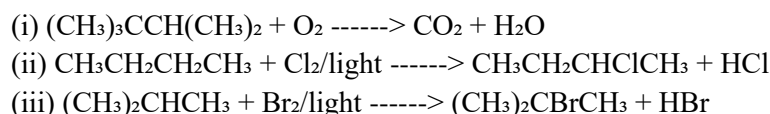
Total pressure = 4 atm

$$\begin{aligned}
 \text{(i) } K_p &= (P_{\text{PCl}_3} \times P_{\text{Cl}_2}) / P_{\text{PCl}_5} \\
 &= [(0.1/1.1) \times 4]^2 / [(0.9/1.1) \times 4] \\
 &= (0.36/3.6) \\
 &= 0.1 \text{ atm}
 \end{aligned}$$

(ii) At 20% dissociation:

$$\begin{aligned}
 \text{Total moles} &= 1 - 0.2 + 0.2 + 0.2 = 1.2 \\
 \text{Using } P_{\text{total}} / n_{\text{total}} &= \text{constant,} \\
 \text{New total pressure} &= 4 \times (1.2 / 1.1) = 4.36 \text{ atm}
 \end{aligned}$$

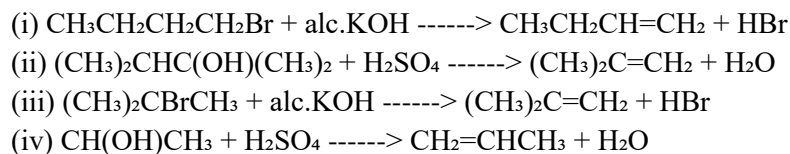
11. (a) Complete the following equations:



(b) Structural isomers of alkylcyclohexane (C_8H_{12}):

1. Methylcyclohexane
2. Ethylcyclopentane
3. Dimethylcyclopentane

(c) Alkenes preparation:



12. (a) Write the structure of the functional groups of the following sets of compounds:

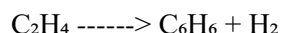
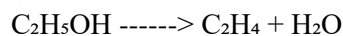
- (i) Alkanes: $-\text{CH}_3$ (single-bonded hydrocarbons)
- (ii) Alkenes: $-\text{CH}=\text{CH}_2$ (double-bonded hydrocarbons)
- (iii) Alkynes: $-\text{C}\equiv\text{C}-$ (triple-bonded hydrocarbons)
- (iv) Alcohols: $-\text{OH}$ (hydroxyl functional group)
- (v) Ketones: $-\text{C}=\text{O}-$ (carbonyl functional group within the chain)
- (vi) Aldehydes: $-\text{CHO}$ (carbonyl functional group at the end of the chain)
- (vii) Carboxylic acid: $-\text{COOH}$ (carboxyl functional group)
- (viii) Tertiary amines: $-\text{N}(\text{CH}_3)_2$ (a nitrogen atom bonded to three carbon atoms)

(b) Give the IUPAC names of the following compounds:

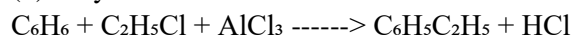
- (i) 2-Methylhexane
- (ii) 3,3-Dimethylheptane
- (iii) 3-Methyl-1-butyne
- (iv) 2,4-Hexyne
- (v) 2-Methyl-1-butene
- (vi) 3-Methyl-1-butyne

13. With support of chemical reactions, show how the following compounds can be prepared from ethanol as a source of carbon atoms:

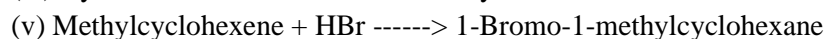
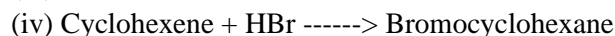
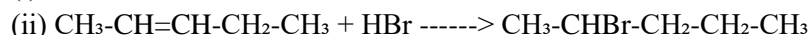
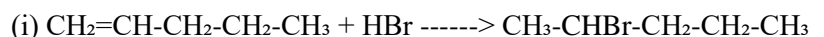
- (a) Benzene



- (b) Ethyl benzene



14. (a) Write the structure of the major products for the reaction of gaseous hydrogen bromide with the following:



(b) Explain how you can distinguish the following compounds:

(i) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$ and $\text{CH}_2=\text{CHCH}_2\text{CH}_3$: Bromine water test (alkene decolorizes bromine water).

(ii) $\text{CH}_3\text{CHCHCH}_3$ and $\text{CH}_3\text{C}\equiv\text{CH}$: Baeyer's test (alkyne reacts with ammoniacal silver nitrate).

(iii) $\text{CHCCH}_2\text{CH}_3$ and $\text{CH}_3\text{C}\equiv\text{CCH}_3$: Tollen's test (terminal alkynes form precipitate).

(iv) Phenol (OH attached to benzene) and Cyclohexanol (OH attached to a saturated ring): Ferric chloride test (phenol gives a violet color).

(v) Benzaldehyde and Benzyl alcohol: Tollen's test (benzaldehyde gives silver mirror).