THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

032/1 **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 thirteen questions

2. Answer all questions.

1. For each of the items (i) - (x), choose the correct answer among the given alternatives and write its letter beside the item number in the answer booklet provided.

(i) Which action should be taken immediately after concentrated sulfuric acid spilled on the skin?

A Its should be rinsed off with large quantities of running water.
B It should be neutralized with solid $CaCO_3$.
C It should be neutralized with concentrated NaOH.
D The affected area should be wrapped tightly and shown to a medical health provider.
E It should be neutralized with concentrated KOH.

Concentrated sulfuric acid is highly corrosive. The best immediate action is to rinse it off with a large amount of running water to dilute and remove it from the skin. Neutralizing with a base is not recommended because the reaction can generate heat and cause further burns.

Correct answer: A

(ii) In the titration of a monoprotic acid with a solution of sodium hydroxide of known concentration, what quantities will be equal at the equivalence point?

A concentration of hydroxide solution and hydronium ions.
B number of moles of hydroxide ions added and number of moles of hydronium ion initially present.
C number of moles of hydroxide solution added and volume of acid solution initially present.
D number of moles of hydroxide ion added and the number of moles of monoprotic acid initially present.
E volume of sodium hydroxide solution added and volume of acid solution initially present.

At the equivalence point of an acid-base titration, the number of moles of hydroxide ions added equals the number of moles of acid originally present.

Correct answer: D

(iii) The charge of one mole of electrons is represented by the term

A one ampere
B one coulomb
C one volt
D one faraday
E one gram.

One faraday represents the charge carried by one mole of electrons and is equal to approximately 96,500 coulombs.

Correct answer: D

(iv) 65.25 g sample of $CuSO_4 \cdot 5H_2O$ (M = 249.7) was dissolved in water to make 0.800 L of solution. What volume of this solution must be diluted with water to make 1.00 L of 0.100 M $CuSO_4$?

A 3.27 ml
B 383 ml
C 209 ml
D 65.25 ml
E 306 ml.

Using the dilution formula:
$C_1V_1 = C_2V_2$

(0.800 L) (65.25 g / 249.7 g/mol) = (1.00 L) (0.100 M)
$V_1 = (0.100 \times 1.00) / (65.25/249.7 \times 0.800)$
$V_1 \approx 306$ ml

Correct answer: E

(v) Consider the system at equilibrium: $H_2O(l) \rightleftharpoons H_2O(g)$ for which $\Delta H > 0$. Which change(s) will increase the yield of $H_2O(g)$?

A Increase in temperature
B Increase in the volume of the container
C Increase in temperature and volume of the container
D Increasing surface area of oxygen
E Increasing surface area of reactants.

Since the reaction is endothermic ($\Delta H > 0$), increasing temperature shifts the equilibrium to the right, favoring the formation of $H_2O(g)$. Increasing the volume of the container reduces pressure, further favoring the gaseous state.

Correct answer: C

(vi) As water is added to an acid, the acid becomes

A more acidic and its pH goes down
B more acidic and its pH goes up
C less acidic and its pH goes up
D less acidic and its pH goes down
E neutral and its pH becomes 7.

Diluting an acid reduces the concentration of hydrogen ions (H^+), making the solution less acidic and increasing the pH.

Correct answer: C

(vii) Three elements, X, Y and Z, are in the same period of the periodic table. The oxide of X is amphoteric, the oxide of Y is basic and the oxide of Z is acidic. Which of the following shows these elements arranged in order of increasing atomic number?

A X, Y, Z
B Y, Z, Y
C Z, X, Y
D Y, X, Z
E X, Z, Y.

Elements in a period change from basic to amphoteric to acidic oxides as atomic number increases. The correct sequence is Y (basic), X (amphoteric), and Z (acidic).

Correct answer: D

(viii) Which of the following compounds contains only two elements?

A Magnesium hydroxide
B Magnesium nitride
C Magnesium phosphate
D Magnesium sulphite
E Magnesium sulphate.

A binary compound consists of only two elements. Magnesium nitride (Mg_3N_2) contains only magnesium and nitrogen.

Correct answer: B

(ix) An atom has 26 protons, 26 electrons and 30 neutrons. The atom has

A atomic number 26, mass number 52
B atomic number 56, mass number 30
C atomic number 30, mass number 82
D atomic number 52, mass number 56
E atomic number 26, mass number 56.

Atomic number = number of protons = 26
Mass number = protons + neutrons = 26 + 30 = 56

Correct answer: E

(x) The following equation is a propagation step in the chlorination of methane:

A $Cl_2 \rightarrow Cl^+ + Cl^-$
B $CH_3^+ + Cl^- \rightarrow CH_3Cl$
C $CH_3^+ + Cl_2 \rightarrow CH_3Cl + Cl^-$
D $CH_4 + Cl^+ \rightarrow CH_3Cl + H^+$
E $CH_3 + Cl_2 \rightarrow CH_2Cl + Cl^+$.

In a propagation step, a free radical is involved. The correct step involves a methyl radical reacting with chlorine to form chloromethane and another free radical.

Correct answer: E

2. Match the items in List A with the responses in List B by writing the letter of the correct response beside the item number in the answer booklet provided.

List A

(i) Atoms of the same element that contain different numbers of neutrons.
(ii) Display both metallic and non-metallic characteristics.
(iii) Sub-atomic particle not found in the nucleus of the atom.
(iv) The number of protons found in the nucleus of the atom.
(v) The total number of protons and neutrons in the nucleus of the atom.
(vi) The number of unpaired electrons on an atom.
(vii) Incredibly stable and rarely reacts.
(viii) Form diatomic molecules.
(ix) Sub-atomic particle with no charge.
(x) A group of atoms with unpaired electrons.

List B

A Atomic number
B Covalent bond
C Electron
D Radical
E Metalloids
F Isotopes
G Mass number
H Neutron
I Allotropes

J Noble gases
K Period
L Group
M Proton
N Valence
O Ions
P Atomic radii
Q Molecules
R Group II elements
S Transition metals
T Halogens

(i) F
(ii) E
(iii) C
(iv) A
(v) G
(vi) N
(vii) J
(viii) T
(ix) H
(x) D

3. (a) Study the following portion of the periodic table with some elements represented by letters and answer the questions that follow.

(i) State how electronegativity varies from A to C and from B to D.

Electronegativity increases from A to C because electronegativity increases across a period due to an increase in nuclear charge, which pulls electrons more strongly.
Electronegativity decreases from B to D because it decreases down a group due to an increase in atomic radius and shielding effect, which reduces the effective nuclear attraction on valence electrons.

(ii) Write the electronic configurations of A, C^{2+}, D and B.

- A (Group II element): 2, 8, 2
- C^{2+} (Group IV element, losing 2 electrons): 2, 8, 2
- D (Group VII element): 2, 8, 7
- B (Group VI element): 2, 8, 6

(b) In the blast furnace, iron ore can be reduced using coke at a temperature of about 1300°C.

(i) Write an equation for the exothermic reaction that causes this high temperature.

$C + O_2$ ----> CO_2 + heat

(ii) State how carbon monoxide is formed.

Carbon monoxide is formed when carbon dioxide reacts with excess coke in the furnace:
$CO_2 + C$ ------> 2CO

(iii) Write a word equation for the formation of slag.

Calcium oxide + Silicon dioxide --------> Calcium silicate (slag)

4. (a) (i) What are the types of oxides formed by elements with atomic numbers 11 and 12?

- Sodium (atomic number 11) forms a basic oxide (Na_2O).
- Magnesium (atomic number 12) forms a basic oxide (MgO).

(ii) Write an equation which represents a reaction between the element with atomic number 11 and 17.

$2Na + Cl_2$ -----> 2NaCl

(iii) Write a balanced chemical equation between the oxide of the element with atomic number 11 and aqueous solution of the compound formed in 4 (a) (ii).

$Na_2O + H_2O$ ----> 2NaOH

(b) (i) What is soil erosion?

Soil erosion is the removal of the top layer of soil by natural forces such as wind, water, and human activities, reducing soil fertility.

(ii) Explain four factors affecting soil erosion.

- Rainfall intensity: Heavy rain dislodges and washes away soil particles.
- Slope of land: Steeper slopes allow faster runoff, increasing soil erosion.
- Vegetation cover: Dense vegetation reduces erosion by binding soil with roots.
- Human activities: Deforestation and overgrazing remove protective cover, accelerating erosion.

5. (a) Giving four reasons, explain why people who use hard water can expect higher costs than people who use soft water.

- Hard water forms scales in pipes and appliances, reducing efficiency and requiring frequent maintenance.
- More soap is needed for washing because hard water does not lather easily.
- Hard water can cause clogging in water heaters and boilers, increasing energy costs.
- Industries using hard water need water softening processes, increasing operational costs.

(b) Suggest one method for the separation of each of the following:

(i) Iodine and sand – Sublimation (Iodine sublimes, sand does not).
(ii) Green solution from leaves – Filtration (Removes solid plant materials).
(iii) Alcohol and water – Distillation (Alcohol has a lower boiling point).
(iv) Iron fillings and powdered calcium carbonate – Magnetic separation (Iron is magnetic, calcium carbonate is not).

6. (a) (i) State three characteristics of a homologous series.

- Same general formula for all members.
- Gradual change in physical properties down the series.
- Similar chemical properties due to the same functional group.

(ii) Draw the displayed/open structure formula of 2, 2-dichlorohexane.

CH_3-CH(Cl)-CH_2-CH_2-CH(Cl)-CH_3

(iii) Giving two reasons, explain why 2, 2-dichloro-3-methylbutane is a structural isomer of 2, 2-dichloropentane.

- Both compounds have the same molecular formula ($C_5H_{10}Cl_2$) but different structures.
- The position of the chlorine atoms and methyl group differs, altering the carbon chain arrangement.

(b) Carbon monoxide and hydrogen are used in the manufacture of methanol and the equilibrium is established according to the following equation.

$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$ ΔH=-80 kJ mol^{-1}.

(i) Give two features of the reaction at equilibrium.

- The rate of the forward and reverse reactions are equal.
- The concentrations of reactants and products remain constant.

(ii) Explain why an increase in temperature causes a decrease in equilibrium yield of methanol.

Since the reaction is exothermic (ΔH=-80 kJ/mol), increasing temperature shifts the equilibrium position towards the reactants (CO and H_2), reducing methanol yield.

7. (a) Briefly explain how aluminum is obtained from its oxide.

Aluminum is extracted from bauxite ore using the Hall-Héroult process:
- Electrolysis of molten alumina (Al_2O_3) dissolved in cryolite is performed.
- At the cathode, Al^{3+} ions gain electrons and are reduced to molten aluminum.
- At the anode, oxygen reacts with carbon anodes to form CO_2.

(b) Write down the chemical equations of the reactions between the following:

(i) Ethanol and sodium metal
$2C_2H_5OH + 2Na$ -----> $2C_2H_5ONa + H_2$

(ii) Propanol warmed with excess acidified potassium permanganate
$CH_3CH_2CH_2OH + 2[O]$ ----> $CH_3CH_2COOH + H_2O$

(iii) Propanol and acetic acid warmed together in the presence of concentrated sulfuric acid.
$CH_3CH_2CH_2OH + CH_3COOH$ ------> $CH_3COOCH_2CH_2CH_3 + H_2O$

8. (a) 25 cm^3 of 0.1 M HCl were neutralized by 23 cm^3 of sodium hydroxide solution. Calculate the concentration of the alkali in grams per liter.

Using $M_1V_1 = M_2V_2$:
$(0.1 \times 25) = (C \times 23)$
$C = (0.1 \times 25) / 23$
$C = 0.1087$ M

Mass per liter = $0.1087 \times 40 = 4.35$ g/L

(b) Give the meaning of the following terms:

(i) Soil structure – The arrangement of soil particles into aggregates affecting porosity and drainage.
(ii) Acidic soil – Soil with a pH below 7 due to high hydrogen ion concentration.
(iii) Liming – The addition of lime ($CaCO_3$) to reduce soil acidity and improve fertility.

11. (b) Fill in the missing values in the following table:

Particle	Relative mass	Charge
Proton	1	+1
Neutron	1	0
Electron	1/1836	-1

12. Causes, Effects, and Prevention of Acid Rain

Cause of Acid Rain

Acid rain is primarily caused by the release of sulfur dioxide (SO_2) and nitrogen oxides (NO_x) into the atmosphere. These pollutants originate mainly from the combustion of fossil fuels in power plants, industrial processes, and vehicles. Once in the atmosphere, SO_2 and NO_x react with water vapor, oxygen, and other chemicals to form sulfuric and nitric acids. These acids then mix with precipitation, resulting in acid rain.

Effects of Acid Rain

1. Environmental Impact: Acid rain leads to the acidification of soils and water bodies, adversely affecting plants and aquatic life. It depletes essential soil nutrients, weakens trees, and disrupts ecosystems by harming fish and other wildlife.

2. Damage to Infrastructure: Acidic precipitation accelerates the deterioration of buildings, monuments, and vehicles by corroding metals and causing paint and stone materials to degrade more rapidly. This results in increased maintenance and repair costs.

Measures to Prevent or Reduce Acid Rain

- Transition to Renewable Energy: Reducing reliance on fossil fuels by adopting renewable energy sources such as solar, wind, and hydroelectric power can significantly decrease SO_2 and NO_x emissions.

- Implementation of Emission Controls: Installing technologies like flue-gas desulfurization units (scrubbers) in power plants can effectively remove sulfur compounds from exhaust gases before they are released into the atmosphere.

- Promotion of Energy Efficiency: Encouraging energy-efficient practices and technologies reduces overall energy consumption, thereby lowering the amount of fossil fuels burned and the associated emissions.

- Enforcement of Environmental Regulations: Governments can establish and enforce regulations that limit the amount of SO_2 and NO_x emissions from industrial sources and vehicles, contributing to the reduction of acid rain.

13. Beneficial and Harmful Effects of Oxides of Carbon, Nitrogen, and Sulfur

The oxides of carbon, nitrogen, and sulfur play complex roles in the environment and human society, exhibiting both beneficial and detrimental effects.

Oxides of Carbon

- Carbon Dioxide (CO_2)

Beneficial: CO_2 is essential for photosynthesis, the process by which plants produce oxygen and energy-rich organic compounds, forming the foundation of most life on Earth.

Harmful: Elevated levels of CO_2 contribute to the greenhouse effect, leading to global warming and climate change, which have widespread environmental and societal impacts.

- Carbon Monoxide (CO)

Beneficial: In controlled environments, CO is utilized in industrial processes, such as the production of certain chemicals and in metallurgical operations.

Harmful: CO is a toxic gas that can impair oxygen delivery in the human body, leading to serious health issues or death upon exposure to high concentrations.

Oxides of Nitrogen

- Nitric Oxide (NO) and Nitrogen Dioxide (NO_2)

Beneficial: In agriculture, nitrogen oxides can contribute to soil fertility by participating in the nitrogen cycle, enhancing plant growth.

Harmful: These gases are significant contributors to air pollution, leading to respiratory problems in humans and contributing to the formation of ground-level ozone and smog.

Oxides of Sulfur

- Sulfur Dioxide (SO_2)

Beneficial: SO_2 is used as a preservative in the food and beverage industry due to its antimicrobial properties.

Harmful: SO_2 can cause respiratory issues in humans and contributes to the formation of acid rain, which damages ecosystems and infrastructure.