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: 2015**

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) The mass number of a carbon atom that contains six protons, eight neutrons, and six electrons is
A 6
B 14
C 8
D 12
E 20.

Mass number = number of protons + number of neutrons
= 6 + 8 = 14
Correct answer: B

(ii) How many moles of oxygen are required for the complete combustion of 2.2 g of C_4H_{10} to form carbon dioxide and water?
A 0.050 moles
B 0.15 moles
C 0.25 moles
D 0.50 moles
E 0.025 moles.

Balanced equation for combustion:
$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$

Molar mass of $C_4H_{10} = (4 \times 12) + (10 \times 1) = 58$ g/mol
Moles of $C_4H_{10} = 2.2$ g / 58 g/mol = 0.0379 moles
From the equation, 2 moles of C_4H_{10} require 13 moles of O_2.
So, 0.0379 moles of C_4H_{10} require $(13/2) \times 0.0379 = 0.246$ moles of $O_2 \approx 0.25$ moles
Correct answer: C

(iii) In the graph below, curve 1 was obtained from the decomposition of 100 cm^3 of 1.0M hydrogen peroxide solution catalysed by manganese (IV) oxide, $2H_2O_2 \rightarrow 2H_2O + O_2$.

Which alteration/change to the original experimental conditions would produce curve 2?
A Lowering the temperature
B Using less manganese IV oxide
C Increasing the temperature
D Adding some 0.1 M H_2O_2
E Using a different catalyst.

Increasing the temperature increases the rate of reaction, leading to a steeper curve.

Correct answer: C

(iv) How long must a current of 4.00 A be applied to a solution of $Cu^{2+}(aq)$ to produce 2.0 grams of copper metal?
A 2.4×10^3 s
B 1.5×10^3 s
C 7.6×10^3 s
D 3.8×10^3 s
E 12×10^3 s.

Using Faraday's law:
m = (ItM) / (nF)

where I = 4.00 A, M = 63.5 g/mol, n = 2, F = 96500 C/mol, and m = 2.0 g.

t = (m × n × F) / (I × M)
= (2.0 × 2 × 96500) / (4.00 × 63.5)
= 7.6×10^3 s

Correct answer: C

(v) Which of the following hydrocarbons does not belong to the same homologous series as the others?
A CH_4
B C_3H_6
C C_4H_{10}
D C_6H_{12}
E C_2H_6.

CH_4, C_2H_6, C_4H_{10}, and C_6H_{12} belong to the alkane family (CnH2n+2), while C_3H_6 belongs to the alkene family (CnH2n).

Correct answer: B

(vi) A solution of pH 1.6 is best described as
A weak acid
B strong base
C weak base
D strong acid
E neutral solution.

A solution with pH 1.6 is strongly acidic.

Correct answer: D

(vii) Which among the following equations correctly shows the reaction between chlorine gas and water?
A $Cl_2(g) + H_2O \rightarrow Cl_2(aq)$
B $2Cl_2(g) + 2H_2O \rightarrow 4Cl^-(aq) + O_2(g) + 2H^+(aq)$
C $Cl_2(g) + H_2O \rightarrow HCl(aq) + HOCl(aq)$
D $2Cl_2(g) + 2H_2O \rightarrow 2HOCl(aq) + H_2(g)$
E $2Cl_2(g) + 3H_2O \rightarrow ClO_3^-(aq) + 2H_2O$.

Correct equation:
$Cl_2(g) + H_2O \rightarrow HCl(aq) + HOCl(aq)$

Correct answer: C

(viii) Hygroscopic and deliquescent substances can be used as
A oxidising agents
B drying agents
C reducing agents
D weak electrolytes
E catalyst.

Hygroscopic and deliquescent substances absorb moisture and can act as drying agents.

Correct answer: B

(ix) Which among the following pair of substances are allotropes?
A H_2O and H_2O_2
B ^{12}C and ^{14}C
C P_4 and P_8
D H_2 and $2H^+$
E H^+ and H_2O.

Allotropes are different structural forms of the same element. Phosphorus exists as different allotropes such as P_4 and P_8.

Correct answer: C

(x) Water can be obtained from a solution of common salt by
A evaporation
B simple distillation
C filtration
D condensation
E fractional distillation.

Water can be separated from a salt solution by simple distillation.
Correct answer: B

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.

List A

(i) Its hydroxide is used in soil treatment.
(ii) It is obtained from its ore in the blast furnace.
(iii) It gives a lilac colour when placed in a non-luminous flame.
(iv) It forms an insoluble sulphate.
(v) It is in the same group in the periodic table with nitrogen.
(vi) It reacts with hydrogen to form a compound which is a liquid at room temperature.
(vii) It is used in filament lamps.
(viii) It is the strongest oxidizing agent among the halogens.
(ix) It exists in three main forms.
(x) Its chloride is added to food in order to give taste.

List B

A Barium
B Lithium
C Iron
D Potassium
E Oxygen
F Fluorine
G Sulphur
H Argon
I Phosphorus
J Sodium
K Magnesium
L Carbon
M Neon
N Silicon
O Calcium

(i) A
(ii) C
(iii) D
(iv) K
(v) I

(vi) F
(vii) H
(viii) F
(ix) L
(x) J

3. (a) (i) State two conditions required for iron to rust.

- Presence of oxygen
- Presence of water (moisture)

(ii) List two methods which are used to prevent rusting of iron.

- Painting or coating with oil/grease to prevent exposure to air and moisture
- Galvanization (coating iron with zinc) to provide a protective layer

(b) State three properties that make aluminium useful in overhead cables.

- It has a low density, making it lightweight for overhead installations.
- It is a good conductor of electricity, allowing efficient transmission of current.
- It is resistant to corrosion, ensuring durability in outdoor conditions.

4. (a) Give three examples in each of the following:

(i) Solid fuel

- Coal
- Wood
- Charcoal

(ii) Gaseous fuel

- Natural gas (methane)
- Hydrogen gas
- Liquefied petroleum gas (LPG)

(b) The reaction which produces methanol from carbon monoxide and hydrogen is represented by the equation
$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$ $\Delta H = -94kJmol^{-1}$. The reaction is carried out at high pressure to give a good yield of methanol.

(i) Explain why increase in pressure gives a better yield of methanol.

According to Le Chatelier's principle, increasing the pressure favors the side with fewer gas molecules. Since the forward reaction produces only one mole of CH_3OH from three moles of reactants, increasing pressure shifts the equilibrium to the right, increasing methanol yield.

(ii) The value of ΔH is negative. What does this tell about the reaction?

A negative ΔH indicates that the reaction is exothermic, meaning it releases heat as it proceeds.

(iii) With a reason, state whether a high temperature or low temperature will give a better yield of methanol.

A low temperature will give a better yield of methanol because the reaction is exothermic. According to Le Chatelier's principle, lowering the temperature favors the forward reaction, increasing methanol production. However, a compromise temperature is used to balance yield and reaction rate.

5. (a) (i) Explain, in terms of electronic configurations, why sodium and potassium elements have similar chemical properties.

Sodium and potassium belong to Group 1 of the periodic table and have similar electronic configurations. Sodium has an electron configuration of 2.8.1, and potassium has 2.8.8.1. Both elements have one valence electron, making them chemically similar as they tend to lose one electron to form +1 ions.

(ii) State the trend in reactivity of group I elements in the periodic table and give reasons for it.

Reactivity increases down the group because atomic size increases, leading to weaker attraction between the nucleus and the valence electron. This makes it easier for elements lower in the group (e.g., potassium, rubidium) to lose their valence electron compared to elements higher in the group (e.g., lithium, sodium).

(b) Use the knowledge of the periodic table to complete Table 1.

Table 1

S/n	Name of element	Atomic number	Electronic configuration
(i)	Lithium	3	2.1
(ii)	Aluminium	13	2.8.3

6. (a) Table 2 indicates the pH values of soil for some crops to grow.

Crops	Soil pH
Tomato	7.0
Bean	6.0
Cabbage	5.4
Cauliflower	5.6
Celery	6.3
Lettuce	6.1
Onions	5.7
Swede	5.3
Parsley	5.1

(i) Which crop grows best in the most acidic soil?

Parsley (pH 5.1)

(ii) Which crop grows best in the least acidic soil?

Celery (pH 6.3)

(iii) Which crop grows best in neutral soil?

Tomato (pH 7.0)

(b) Suggest one best method for separating each of the following mixtures:

(i) Common salt and water

Simple distillation (to separate water by evaporation and condensation)

(ii) Iodine and sand

Sublimation (iodine sublimes when heated, leaving sand behind)

(iii) Pieces of iron and sand

Magnetic separation (iron is attracted to a magnet while sand is not)

7. (a) Briefly explain what will happen when

(i) Concentrated sulfuric acid is exposed to the atmosphere?

It absorbs moisture from the air because it is highly hygroscopic and eventually becomes diluted.

(ii) Iron(II) sulfate is exposed to air for a long time?

It gets oxidized to iron(III) sulfate, changing from green to brown due to the formation of iron(III) hydroxide.

(iii) A bottle containing $AgNO_3$ is left open?

Silver nitrate undergoes photodecomposition in the presence of light, turning dark due to the formation of silver metal.

(b) Give three applications of the process of neutralization in daily life.

- Treating acidic soil by adding lime to improve agricultural productivity.
- Using antacids (magnesium hydroxide) to relieve indigestion caused by excess stomach acid.
- Treating acidic industrial wastewater before releasing it into water bodies.

8. (a) Give the names or formula of the two chemicals that would be used in the laboratory to make each of the following gases. State a simple test that could be used to identify each gas.

(i) Oxygen

Chemicals: Hydrogen peroxide (H_2O_2) and manganese(IV) oxide catalyst
Test: Insert a glowing splint into the gas; it relights in the presence of oxygen.

(ii) Hydrogen

Chemicals: Zinc (Zn) and dilute hydrochloric acid (HCl)
Test: A burning splint produces a "pop" sound in hydrogen gas.

(iii) Carbon dioxide

Chemicals: Calcium carbonate ($CaCO_3$) and dilute hydrochloric acid (HCl)
Test: Bubble the gas through limewater; if it turns milky, carbon dioxide is present.

(b) Suggest a suitable indicator for the following titrations:

(i) Hydrochloric acid against ammonia solution.

Methyl orange (changes from red to yellow at endpoint)

(ii) Sulfuric acid against sodium hydroxide solution.

Phenolphthalein (changes from pink to colorless at endpoint)

(iii) Ethanoic acid against potassium hydroxide solution.

Methyl orange (changes from red to yellow at endpoint)

9. (a)(i) What type of chemical bond is found between fluorine atoms in a fluorine molecule?

Covalent bond (a shared pair of electrons between fluorine atoms)

(ii) Name other type(s) of chemical bond formed by fluorine with other elements. Give an example of a compound in which fluorine forms this type of bond.

Ionic bond (when fluorine gains an electron to form F^- ion)
Example: Sodium fluoride (NaF)

(b) Compound X contains 24.24% carbon, 4.04% hydrogen, and 71.72% chlorine. Given that the vapor density of X is 49.5.

(i) Calculate the molecular formula of the compound X.

Step 1: Convert mass percentages to moles

Moles of C = 24.24 / 12 = 2.02
Moles of H = 4.04 / 1 = 4.04
Moles of Cl = 71.72 / 35.5 = 2.02

Step 2: Divide by the smallest number of moles

C = 2.02 / 2.02 = 1
H = 4.04 / 2.02 = 2
Cl = 2.02 / 2.02 = 1

Empirical formula: CH_2Cl

Step 3: Determine the molecular formula

Empirical formula mass = 12 + (2 × 1) + 35.5 = 49.5

Since the molecular mass (2 × vapor density) = 49.5 × 2 = 99, the empirical formula and molecular formula are the same.

Molecular formula: CH_2Cl_2

(ii) Draw and name the displayed/open structure formula of the possible isomer(s) from the molecular formula determined.

Possible isomers:
- Dichloromethane (CH_2Cl_2) with different spatial arrangements of chlorine atoms.

10. (a) A student tested four samples of water, each 5 cm^3 from different areas of Kahama district by shaking with 3 drops of soap solution. The experiment was repeated by boiling each sample of water (5 cm^3) with 3 drops of soap solution. The observations were recorded in Table 3.

Table 3

Sample	Observation with soap solution	Observation for boiled sample with soap solution
A	No lather	Lather
B	Lather	Lather
C	Lather	Lather
D	No lather	No lather

(i) Which samples contain hard water?

Samples A and D contain hard water because they did not form a lather with soap solution before boiling.

(ii) Which sample contains temporary hard water? Give a reason.

Sample A contains temporary hard water because it did not form a lather before boiling but formed a lather after boiling. This indicates the removal of temporary hardness, which is caused by dissolved bicarbonates that decompose upon heating.

(b) Protons, neutrons, and electrons particles are located in the atoms; fill in the missing information in Table 4 about these particles.

Table 4

Particles	Relative mass	Relative charge	Location
Proton	1	+1	In the nucleus
Electron	1/1836	-1	Outside the nucleus
Neutron	1	0	In the nucleus

11. (a) A steady current of 2A was passed through a solution containing ions of a metal (X^{2+}) for nine minutes. The mass of metal X that was liberated was 0.3552 g. Calculate the molar mass of metal X.

Using Faraday's first law of electrolysis:

$m = (ItM) / (nF)$

Where:
I = 2A,
t = 9 min = 9 × 60 = 540 s,
F = 96500 C/mol,
n = 2 (since X^{2+})

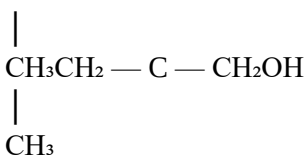
Rearrange the formula to solve for M:

$M = (m \times n \times F) / (I \times t)$
$M = (0.3552 \times 2 \times 96500) / (2 \times 540)$
$M = 63.5$ g/mol

The metal X is Copper (Cu).

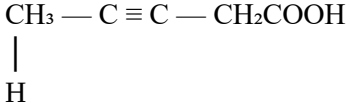
(b) Name the following compounds according to the IUPAC system.
(i) C_5H_{12}
Pentane

(ii)



2-methylbutan-2-ol

(iii)



Pent-2-ynoic acid

12. Describe the extraction of iron from the haematite ore and write all the chemical equations for the reactions involved in each stage of extraction.

Iron is extracted from haematite (Fe_2O_3) in a blast furnace using carbon monoxide as a reducing agent.

(i) Combustion: Carbon (coke) burns in the presence of oxygen to form carbon dioxide.
$C + O_2$ ----> CO_2

(ii) Formation of carbon monoxide: Carbon dioxide reacts with excess coke to form carbon monoxide, which acts as the reducing agent.
$CO_2 + C$ -----> $2CO$

(iii) Reduction of haematite: Carbon monoxide reduces haematite to iron.
$Fe_2O_3 + 3CO$ -------> $2Fe + 3CO_2$

(iv) Removal of impurities (slag formation): Limestone ($CaCO_3$) decomposes to form calcium oxide, which reacts with silica (SiO_2) impurities to form slag ($CaSiO_3$).
$CaCO_3$ ----> $CaO + CO_2$
$CaO + SiO_2$ ------> $CaSiO_3$ (slag)

The molten iron is collected at the bottom of the furnace, while slag floats on top and is removed separately.

13. Addition of inorganic fertilizers in the farm is not as important as the addition of organic manure. Discuss the correctness of this statement in four points.

(i) Nutrient release rate
Organic manure releases nutrients slowly over time, providing a sustainable nutrient supply. Inorganic fertilizers provide immediate nutrients but can be leached away quickly.

(ii) Soil structure improvement
Organic manure improves soil structure, increasing water retention and aeration, while inorganic fertilizers do not improve soil texture.

(iii) Environmental impact
Excessive use of inorganic fertilizers can lead to soil degradation and water pollution due to runoff, whereas organic manure is environmentally friendly and promotes biodiversity.

(iv) Cost and sustainability
Organic manure is cheaper and sustainable, as it can be obtained from farm waste, while inorganic fertilizers are costly and require industrial production.

Both organic manure and inorganic fertilizers are essential, but organic manure provides long-term soil health benefits.