**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**                    <span style="color:red">**ANSWERS**</span>                    **Year: 2014**

**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) An element in the periodic table with atomic number 18 belongs to which of the following?

A Group I and period I.
B Group O and period III.
C Group III and period III.
D Group V and period IV.
E Group VII and period IV.

Argon (Ar) has an atomic number of 18 and is a noble gas in Group 0 (or Group 18) and Period III.

Correct answer: B

(ii) The ionic equation when aqueous ammonium chloride reacts with sodium hydroxide solution is represented as:

A $2NH_4^+(aq) + 2Cl^-(aq) \longrightarrow 2NH_3(g) + Cl_2(g) + H_2(g)$
B $NH_4^+(aq) + OH^-(aq) \longrightarrow NH_3(g) + H_2O(l)$
C $Na^+(aq) + Cl^-(aq) \longrightarrow NaCl(s)$
D $H^+(aq) + OH^-(aq) \longrightarrow H_2O(l)$
E $2NH_4^+(aq) + 2Cl^-(aq) \longrightarrow 2NH_3(g) + 2HCl(g)$

When ammonium chloride reacts with sodium hydroxide, ammonia gas is produced.

Correct answer: B

(iii) The reason why white anhydrous copper(II) sulfate turns blue when exposed in the atmosphere is that it,

A reacts with carbon dioxide.
B reacts with oxygen.
C becomes dry.
D absorbs water vapor.
E decomposes.

Anhydrous copper(II) sulfate absorbs water vapor to form hydrated copper(II) sulfate, which is blue.

Correct answer: D

(iv) Chemical change means;

A the change is reversible.
B can easily be separated.
C the change is complete.
D new substance is produced.
E produces no change of mass.

A chemical change results in the formation of a new substance.

Correct answer: D

(v) If a steady current of 2 amperes was passed through an aqueous solution of iron(II) sulfate for 15 minutes, the mass of iron deposited at the cathode will be:

A 54 g
B 56 g
C 0.54 g
D 28 g
E 0.52 g

Using Faraday's laws of electrolysis:
m = (ItM) / (nF)

where I = 2A, t = 15 min = 900 s, M = 55.85 g/mol (Fe), n = 2, and F = 96500 C/mol.

m = (2 × 900 × 55.85) / (2 × 96500) = 0.52 g

Correct answer: E

(vi) 10 cm³ of 0.4 M sodium hydroxide are added to 40 cm³ of 0.2 M hydrochloric acid. The resulting mixture will be

A Neutral
B Alkaline
C Dilute
D Acidic
E Amphoteric

Moles of NaOH = (0.4 × 10) / 1000 = 0.004 moles
Moles of HCl = (0.2 × 40) / 1000 = 0.008 moles

Since HCl is in excess, the solution will be acidic.

Correct answer: D

(vii) The only metal which does not react with dilute hydrochloric acid is

A Magnesium
B Aluminum
C Copper
D Zinc
E Sodium

Copper does not react with dilute acids because it is less reactive than hydrogen.

Correct answer: C

(viii) Which of the following solutions is the most concentrated?

A 50 g of calcium carbonate in 100 cm³ of water
B 60 g of sodium chloride in 200 cm³ of water
C 65 g of potassium nitrate in 100 cm³ of water
D 120 g of potassium sulfate in 200 cm³ of water
E 50 g of sodium hydroxide in 200 cm³ of water

Concentration = mass/volume

Most concentrated: 65 g of potassium nitrate in 100 cm³ of water.

Correct answer: C

(ix) Alcohols react with carboxylic acids to form a group of organic compounds called

A alkynes
B aldehydes
C ethers
D esters
E alkanols.

Alcohols react with carboxylic acids in esterification to form esters.

Correct answer: D

(x) Which of the following statements is true about water gas?

A It is poisonous.
B Contains hydrogen.

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C Is the same as biogas.

D Contains hydrogen and nitrogen.

E Contains carbon monoxide and hydrogen.

Water gas is a mixture of carbon monoxide and hydrogen.

Correct answer: E

2. Match the items in List A which 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) Its nitrate decomposes to the metal, nitrogen dioxide, and oxygen.

(ii) Its chloride is used as a drying agent for most gases.

(iii) Its carbonate is used to remove hardness of water.

(iv) Has maximum valency of five.

(v) Burns with a lilac color flame.

(vi) Used in the manufacture of ammonia.

(vii) Exists in two main physical forms.

(viii) Greenish-yellow gas.

(ix) The second abundant element in the earth's crust.

(x) Reacts with steam only at red heat to produce metal oxide and hydrogen gas.

List B

A Potassium

B Copper

C Argon

D Calcium

E Sulphur

F Chlorine

G Carbon

H Boron

I Silicon

J Zinc

K Beryllium

L Neon

M Hydrogen

N Helium

O Sodium

P Lead

Q Iodine

R Manganese
S Phosphorus
T Silver

(i) R
(ii) Q
(iii) D
(iv) S
(v) A
(vi) M
(vii) G
(viii) F
(ix) I
(x) J


3. (a) (i) Why chemistry laboratory exits open outward?

Laboratory exits open outward to ensure a quick and easy evacuation during emergencies such as fires, explosions, or chemical spills. This prevents crowding at the door and allows people to push their way out without obstruction.

(ii) State the uses of any four items found in a First Aid Kit.

- Bandages – Used to cover wounds and stop bleeding.
- Antiseptic solution – Used to disinfect wounds and prevent infections.
- Adhesive plasters – Used to cover small cuts and wounds.
- Cotton wool – Used for cleaning wounds and applying antiseptics.

(b)(i) Arrange the following metals in order of increasing reactivity; zinc, magnesium, calcium, copper, and mercury.

Copper < Mercury < Zinc < Magnesium < Calcium

(ii) Which one of the metals in (i) above reacts with steam to form an oxide which is white when cold and yellow when hot?

Zinc reacts with steam to form zinc oxide (ZnO), which is yellow when hot and white when cold.

4. (a) 20 cm³ of a solution containing 7 g dm⁻³ of sodium hydroxide were exactly neutralized by 25 cm³ of 0.10 M hydrochloric acid. Calculate the concentration of sodium hydroxide in moles per dm³.

Molar mass of NaOH = 23 + 16 + 1 = 40 g/mol

6

Concentration in g/dm³ = 7 g/dm³
Molar concentration = 7 g/dm³ ÷ 40 g/mol = 0.175 mol/dm³

(b) Give two examples in each of the following solutions.

(i) Gaseous solution.

- Air (a mixture of gases)
- Carbonated drinks (carbon dioxide dissolved in water)

(ii) Solid solution.

- Alloys such as brass (zinc and copper)
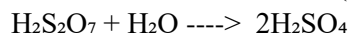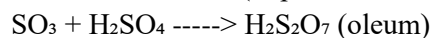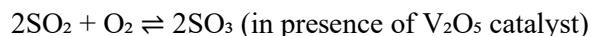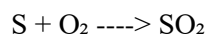- Amalgams (mercury with other metals)

5. (a) Study the following part of the periodic table and list down the names of all the missing elements.

| H | | | | | | | He |
|---|----|----|----|---|---|----|----|
| Li | Be | B | | | | F | |
| | | Al | Si | P | S | Cl | Ar |

(b)  the missing elements.
 C | N | O | Ne | Na | Mg |
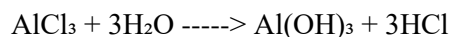
(i) Write the reaction equations involved in the industrial manufacturing of sulfuric acid starting with sulfur dioxide in the contact process.

$S + O_2 \longrightarrow SO_2$
$2SO_2 + O_2 \rightleftharpoons 2SO_3$ (in presence of $V_2O_5$ catalyst)
$SO_3 + H_2SO_4 \longrightarrow H_2S_2O_7$ (oleum)
$H_2S_2O_7 + H_2O \longrightarrow 2H_2SO_4$

(ii) Explain why sulfur trioxide is not dissolved directly in water to obtain sulfuric acid in the contact process.

Dissolving $SO_3$ directly in water forms a mist of sulfuric acid that is difficult to handle. Instead, it is first absorbed in concentrated sulfuric acid to form oleum, which is then diluted with water.

6. (a) With the aid of chemical equations, explain what will happen when aluminum chloride reacts with water.

$AlCl_3 + 3H_2O \longrightarrow Al(OH)_3 + 3HCl$

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Aluminum chloride hydrolyzes in water to form aluminum hydroxide and hydrochloric acid, making the solution acidic.

(b) A student accidentally broke a beaker containing copper(II) sulfate crystals. He decided to separate the blue crystals from the small pieces of glass by first dissolving the mixture and then filtering. What were his next steps?

After filtering, the student should evaporate the filtrate to concentrate the copper(II) sulfate solution, then cool it to allow recrystallization of pure copper(II) sulfate crystals.

7. (a) Table 2 gives some information about the composition of three samples of water from wells in Kahama, Maswa, and Bukombe districts.

(i) State two ways in which these ions get into the samples of water.

- Dissolution of minerals from rocks.
- Agricultural runoff containing dissolved fertilizers.

(ii) Giving two reasons, state the hardest sample of water.

Maswa water is the hardest because it has the highest concentration of calcium (82 mg/L) and magnesium (41 mg/L) ions, which are responsible for water hardness.

(iii) State two ways that can be used to remove ions in (ii).

- Boiling to remove temporary hardness.
- Ion-exchange resins to remove both temporary and permanent hardness.

(b) State and describe the type of reaction in the following chemical equations:

(i) $Fe(s) + CuSO_4(aq) ----> FeSO_4(aq) + Cu(s)$
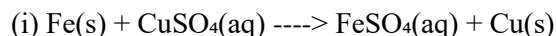
This is a displacement reaction where iron displaces copper from copper(II) sulfate because iron is more reactive than copper.

(ii) $Na_2SO_4(aq) + BaCl_2(aq) ----> BaSO_4(s) + 2NaCl(aq)$
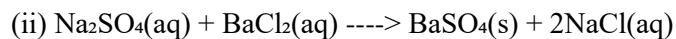
This is a precipitation reaction, where barium sulfate precipitates out of solution.

8. (a) The following are the general structural formulae of certain organic compounds: R-OH, R-COOH, and RCOOR'.

(i) Name the homologous series represented by R-OH, R-COOH, and RCOOR'.

- R-OH: Alcohols
- R-COOH: Carboxylic acids
- RCOOR': Esters

(ii) Functional groups represented by R-OH and R-COOH.

- R-OH: Hydroxyl (-OH) group
- R-COOH: Carboxyl (-COOH) group

(b) When a burning splint is introduced into a gas jar containing carbon dioxide, the flame goes out.

(i) What two properties of carbon dioxide does this experiment illustrate?

- Carbon dioxide does not support combustion.
- It is denser than air.

(ii) What type of equipment used widely in everyday life makes use of these two properties?

Fire extinguishers use carbon dioxide to put out fires because it displaces oxygen and cools the flames.

9. (a) Differentiate between:

(i) A base and an alkali.

- A base is a substance that reacts with acids to form salt and water.
- An alkali is a base that dissolves in water to produce hydroxide ions ($OH^-$).

(ii) Atom and isotopes.

- An atom is the smallest unit of an element that retains its chemical properties.
- Isotopes are atoms of the same element with different numbers of neutrons.

(b) An organic compound P consists of 52.2% carbon, 13% hydrogen, and 34.8% oxygen. The vapor density of P is 23. Calculate the molecular formula of the compound P and write possible isomer(s) from the molecular formula determined.

Step 1: Convert mass percentages to moles.

C = 52.2/12 = 4.35
H = 13/1 = 13
O = 34.8/16 = 2.175

Step 2: Divide by the smallest value.

C = 4.35 / 2.175 = 2
H = 13 / 2.175 = 6
O = 2.175 / 2.175 = 1
Empirical formula: $C_2H_6O$

Step 3: Determine the molecular formula.

Molecular mass = 2 × vapor density = 2 × 23 = 46 g/mol
Empirical formula mass = (2 × 12) + (6 × 1) + (1 × 16) = 46 g/mol

Since the empirical and molecular masses are equal, the molecular formula is $C_2H_6O$.
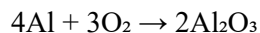Possible isomers:
- Ethanol ($CH_3CH_2OH$)
- Dimethyl ether ($CH_3OCH_3$)

10. (a) Aluminium reacts with oxygen to form aluminium oxide. How many grams of potassium chlorate would be heated to produce enough oxygen to form 5.1 g of aluminium oxide?

Step 1: Write the balanced equation for aluminium oxide formation
$4Al + 3O_2 \rightarrow 2Al_2O_3$

Step 2: Calculate the moles of $Al_2O_3$ formed
Molar mass of $Al_2O_3$ = (2 × 27) + (3 × 16) = 102 g/mol
Moles of $Al_2O_3$ = 5.1 g / 102 g/mol = 0.05 moles
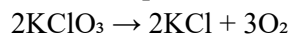
Step 3: Determine moles of $O_2$ required
From the equation, 2 moles of $Al_2O_3$ require 3 moles of $O_2$
0.05 moles of $Al_2O_3$ will require (3/2) × 0.05 = 0.075 moles of $O_2$

Step 4: Determine the mass of $KClO_3$ needed to produce 0.075 moles of $O_2$
The decomposition reaction of potassium chlorate:
$2KClO_3 \rightarrow 2KCl + 3O_2$

From the equation, 2 moles of $KClO_3$ produce 3 moles of $O_2$
Moles of $KClO_3$ required = (2/3) × 0.075 = 0.05 moles

Step 5: Calculate mass of $KClO_3$
Molar mass of $KClO_3$ = 39 + 35.5 + (3 × 16) = 122.5 g/mol
Mass of $KClO_3$ = 0.05 × 122.5 = 6.13 g

Thus, 6.13 g of potassium chlorate would be heated to produce enough oxygen for 5.1 g of aluminium oxide.

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(b) The preparation of chlorine gas can be represented by the following equation:

$MnO_2 + 4HCl \longrightarrow MnCl_2 + 2H_2O + Cl_2$

How many moles of HCl are needed to react with 25 g of $MnO_2$?

Step 1: Find moles of $MnO_2$

Molar mass of $MnO_2 = (55) + (2 \times 16) = 87$ g/mol

Moles of $MnO_2 = 25$ g / 87 g/mol = 0.287 moles

Step 2: Determine moles of HCl required

From the equation, 1 mole of $MnO_2$ reacts with 4 moles of HCl

Moles of HCl $= 0.287 \times 4 = 1.15$ moles

Thus, 1.15 moles of HCl are needed to react with 25 g of $MnO_2$.

11. (a)

(i) List four effects of excessive nitrogen to plants.

- Excess nitrogen promotes excessive vegetative growth, causing plants to become weak and prone to lodging (falling over).
- High nitrogen levels can delay flowering and fruit production, reducing overall yield.
- Excessive nitrogen can lead to nutrient imbalances in the soil, making other essential nutrients like phosphorus and potassium less available.
- It increases susceptibility to pests and diseases due to rapid but weak tissue growth.

(ii) State two ways through which soil nitrogen can be lost.

- Leaching: Excess nitrogen in the form of nitrates can dissolve in water and be washed away from the soil, reducing its availability to plants.
- Denitrification: Microorganisms in the soil convert nitrates into nitrogen gas ($N_2$) and release it into the atmosphere, reducing soil fertility.

(b) Oxygen and ethanol react to produce carbon dioxide and water according to the following energy level diagram:

(i) What is represented by letter A, B and C?

- A represents the reactants (oxygen and ethanol before reaction).
- B represents the activation energy (the minimum energy required for the reaction to start).
- C represents the products (carbon dioxide and water formed after the reaction).

(ii) What type of reaction is represented by this energy level diagram?

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This is an exothermic reaction because the energy level of the products is lower than that of the reactants. This means that energy is released in the form of heat during the reaction, which is characteristic of combustion reactions.

12. Assume that you are a chemist in a chemical plant that deals with the production of chlorine gas. You want to produce 100 litres of chlorine gas per hour so that you can reach the company's goal of producing 2400 litres every day. What current of electricity will you allow to flow per hour?

Step 1: Use Faraday's law for electrolysis of NaCl solution
The half-equation for chlorine gas production:
$2Cl^- -----> Cl_2 + 2e^-$
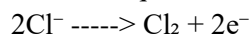
Step 2: Determine moles of chlorine gas
Molar volume of gas at STP = 22.4 L/mol
Moles of $Cl_2$ = 100 L / 22.4 L/mol = 4.464 moles

Step 3: Calculate charge required
From the equation, 1 mole of $Cl_2$ requires 2 moles of electrons.
Moles of electrons = $4.464 \times 2 = 8.928$ moles

Charge (Q) = moles of electrons × Faraday's constant
$Q = 8.928 \times 96500$ C/mol = 861572 C

Step 4: Calculate current (I)
$I = Q / t$
t = 3600 s (1 hour)
$I = 861572 / 3600 = 239.3$ A

Thus, a current of approximately 239 A should be allowed to flow per hour.

13. Describe five causes and effects of soil pollution.

(i) Industrial waste disposal
Cause: Factories discharge harmful chemicals and heavy metals into the soil, leading to contamination.
Effect: Toxic substances accumulate in the soil, making it unfit for plant growth and harmful to organisms.

(ii) Excessive use of chemical fertilizers and pesticides

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Cause: Over-application of synthetic fertilizers and pesticides leads to soil degradation and accumulation of harmful residues.
Effect: Reduces soil fertility over time and contaminates groundwater, affecting human and animal health.

(iii) Deforestation
Cause: Clearing forests for agriculture or urbanization removes tree cover, leading to soil erosion and exposure to pollutants.
Effect: Loss of nutrients in the topsoil, making the land less productive for farming.

(iv) Oil spills and petroleum products
Cause: Leakage from oil storage facilities, transportation pipelines, and accidental spills.
Effect: Contaminates soil, making it difficult for plants to grow and pollutes underground water sources.

(v) Improper waste disposal
Cause: Dumping of non-biodegradable plastics, electronic waste, and hazardous materials.
Effect: Accumulation of toxic substances in the soil, affecting biodiversity and agricultural productivity.

Soil pollution poses a serious threat to food security, human health, and the environment. Implementing proper waste management and sustainable agricultural practices can help mitigate its effects.

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