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 **Year: 2023**

Instructions

1. This paper consists of sections A, B and C with total of thirteen questions

2. Answer all questions.

(i) Which is the correct description of nucleons?
A. Nucleons are neutrons and protons in the nucleus of an atom.
B. Nucleons are neutrons in the nucleus of an atom.
C. Nucleons are protons and electrons in the nucleus of an atom.
D. Nucleons are neutrons and electrons in the nucleus of an atom.
E. Nucleons are neutrons, protons, and electrons in the nucleus of an atom.

Answer:
Nucleons are particles found in the nucleus of an atom and consist of protons and neutrons. Electrons are not considered nucleons as they orbit around the nucleus.
The correct answer is A. Nucleons are neutrons and protons in the nucleus of an atom.

(ii) Which one of the following characterizes ions formation? A.
Metal atoms gaining electrons in their outermost shells.
B. Non-metal atoms losing electrons from their outermost shells.
C. Metal atoms losing electrons from their innermost shells.
D. Non-metal atoms gaining electrons in their innermost shells.
E. Metal atoms losing electrons from their outermost shells.

Answer:
Ion formation occurs when metal atoms lose electrons from their outermost shells to form cations, or when non-metal atoms gain electrons in their outermost shells to form anions.
The correct answer is E. Metal atoms losing electrons from their outermost shells.

(iii) The following are steps of writing ionic equation except A.
Writing the correct formula for the reaction.
B. Writing all soluble ionic substances.
C. Writing the reaction in words.
D. Writing all insoluble ionic products.
E. Writing balanced formula equation for the reaction.

Answer:
Writing ionic equations involves using chemical symbols and formulas, not words. Therefore, writing the reaction in words is not part of the process.
The correct answer is C. Writing the reaction in words.

(iv) A Form Two student was given the following materials for preparation of oxygen gas: (i)
Source of heat
(ii) Manganese dioxide
(iii) Hydrogen peroxide
(iv) Potassium chlorate

Which combination will fast produce oxygen?

A. (ii) and (iv)
B. (i) and (iii)
C. (iii) and (iv)
D. (i), (iii) and (iv)
E. (i), (ii) and (iv) Answer:
Manganese dioxide acts as a catalyst when hydrogen peroxide is decomposed, producing oxygen gas quickly. Potassium chlorate decomposes under heat to release oxygen gas. Hence, a combination of (i) source of heat, (ii) manganese dioxide, and (iv) potassium chlorate will rapidly produce oxygen.
The correct answer is E. (i), (ii) and (iv).
(vi) Consider the given trends in physical properties of elements in the Periodic Table:
(i) Electron affinity increases from left to right.
(ii) Density increases down the group.
(iii) Melting point of metals increases down the group.
(iv) Metallic character decreases from left to right.

What combination demonstrates correct trends?
A. (iii) and (iv)
B. (i) and (iii)
C. (i) and (ii)
D. (ii) and (iii)
E. (i) and (iv)

Answer:
Electron affinity increases from left to right across a period, as elements gain more protons, increasing their attraction for electrons. Metallic character decreases from left to right because non-metallic properties become dominant.
The correct answer is E. (i) and (iv).

(vii) The organic compounds marked A and B reacted together to form compound C as shown in the equation:

$CH_3CH_2OH + CH_3COOH \rightarrow CH_3COOCH_2CH_3$

What are the names of compounds A, B, and C? A.
Ester, carboxylic acid, and alcohol.
B. Alcohol, carboxylic acid, and ester. C.
Alcohol, ester, and carboxylic acid.
D. Ethanol, ethanoic acid, and ethylethanoate.
E. Carboxylic acid, ethanol, and ethylethanoate.

Answer:
The reaction is an esterification process, where ethanol (alcohol, A) reacts with ethanoic acid (carboxylic acid, B) to form ethyl ethanoate (ester, C).

The correct answer is D. Ethanol, ethanoic acid, and ethylethanoate.

(viii) Which of the following does not constitute one mole? A.
32 g of oxygen molecules.
B. 2 g of hydrogen molecules.
C. 19 g of hydroxonium ions.
D. 28 g of carbon monoxide molecules.
E. 49 g of sulphuric acid.

Answer:
One mole of a substance corresponds to its molar mass.
- Oxygen (O_2): Molar mass = 32 g/mol → 32 g is one mole.
- Hydrogen (H_2): Molar mass = 2 g/mol → 2 g is one mole.
- Hydroxonium ion (H_3O^+): Molar mass ≈ 19 g/mol → 19 g is one mole.
- Carbon monoxide (CO): Molar mass = 28 g/mol → 28 g is one mole.
- Sulphuric acid (H_2SO_4): Molar mass = 98 g/mol → 49 g is not one mole (it is half a mole).

The correct answer is E. 49 g of sulphuric acid.

(ix) Permanent hardness of water can be removed by using washing soda. Which reaction is the correct ionic equation for the softening process?
A. $Ca^{2+}(aq) + SO_4^{2-}(aq) \rightarrow CaSO_4(aq)$
B. $Ca^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s)$
C. $Mg^{2+}(aq) + SO_4^{2-}(aq) \rightarrow MgSO_4(aq)$
D. $Ca^{2+}(aq) + 2HCO_3^{-}(aq) \rightarrow Ca(HCO_3)_2(aq)$
E. $Mg^{2+}(aq) + 2HCO_3^{-}(aq) \rightarrow Mg(HCO_3)_2(aq)$

Answer:
Washing soda (Na_2CO_3) removes permanent hardness by precipitating calcium and magnesium ions as insoluble carbonates. The reaction for calcium ions is:
$Ca^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s)$

The correct answer is B. $Ca^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s)$.

(x) Why sodium hydroxide pellets should be stored in a closed container? A.
Sodium hydroxide is efflorescence.
B. Sodium hydroxide is hygroscopic.
C. Sodium hydroxide is deliquescent.
D. Sodium hydroxide is volatile.
E. Sodium hydroxide is flammable.
Answer:

Sodium hydroxide is hygroscopic, meaning it absorbs moisture from the air, and is deliquescent, meaning it can dissolve in the absorbed water. To prevent this, it must be stored in a closed container.
The correct answer is B. Sodium hydroxide is hygroscopic.
2. Match the chemical equations in List A with the corresponding types of chemical reactions in List B by writing the letter of the correct response beside the item number in the answer booklet provided.

List A:
(i) $NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$
(ii) $C(s) + O_2(g) \rightarrow CO_2(g) + Heat$
(iii) $2C(s) + 2H_2(g) + Heat \rightarrow C_2H_4(g)$
(iv) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
(v) $H_2SO_4(aq) + 2KOH(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l)$
(vi) $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

List B:
A. Endothermic reaction
B. Ionic reaction
C. Exothermic reaction
D. Neutralization reaction
E. Reversible reaction
F. Homogeneous reaction
G. Displacement reaction
H. Decomposition reaction

Answer:
(i) $NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$ - B. Ionic reaction
Explanation: Ammonia and hydrogen chloride react to form an ionic compound (ammonium chloride).

(ii) $C(s) + O_2(g) \rightarrow CO_2(g) + Heat$ - C. Exothermic reaction Explanation: This reaction releases heat, making it exothermic.

(iii) $2C(s) + 2H_2(g) + Heat \rightarrow C_2H_4(g)$ - A. Endothermic reaction
Explanation: Heat is absorbed during this reaction, making it endothermic.

(iv) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ - E. Reversible reaction
Explanation: This reaction can proceed in both forward and backward directions, making it reversible.

(v) $H_2SO_4(aq) + 2KOH(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l)$ - D. Neutralization reaction
Explanation: Sulfuric acid and potassium hydroxide react to neutralize each other, forming salt and water.

(vi) $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$ - H. Decomposition reaction

Explanation: Calcium carbonate decomposes into calcium oxide and carbon dioxide.

3. Using a schematic diagram, illustrate the correct sequence of urban water treatment.

Answer:
The process of urban water treatment typically involves:
- Intake: Water is drawn from a source such as a river or lake.
- Screening: Large debris such as leaves and sticks are removed using screens.
- Coagulation and Flocculation: Chemicals like alum are added to form flocs that trap dirt and impurities.
- Sedimentation: Flocs settle to the bottom of a sedimentation tank.
- Filtration: Water passes through layers of sand, gravel, and charcoal to remove smaller particles.
- Disinfection: Chlorine or UV light is used to kill harmful microorganisms.
- Storage: Treated water is stored in reservoirs before being distributed to consumers.

4. (a) Briefly explain the importance of a laboratory coat, safety goggles, gloves, and protective masks as safety equipment in the chemistry laboratory.

Answer:
- Laboratory coat: Protects the body and clothes from chemical spills and splashes.
- Safety goggles: Shields the eyes from harmful chemical fumes, splashes, and particles.
- Gloves: Protects hands from corrosive substances, biological agents, and toxic chemicals.
- Protective masks: Prevents inhalation of hazardous fumes, dust, and airborne particles.

(b) Identify the uses of the given apparatus:
(i) Reagent bottle: Used to store chemicals in liquid or powdered form.
(ii) Filter funnel: Used to pour liquids and to separate solids from liquids through filtration.
(iii) Pipette: Used to measure and transfer precise volumes of liquids.
(iv) Mortar and pestle: Used to grind and crush substances into fine powders or paste.
(v) Bunsen burner: Provides a heat source for heating, sterilizing, or combustion in experiments.

5. Explain six scientific procedures used by scientists to investigate scientific problems.

Answer:
- Observation: Identifying a problem through careful observation of phenomena.
- Formulation of a hypothesis: Proposing an explanation based on observations.
- Experimentation: Conducting controlled experiments to test the hypothesis.
- Data collection: Gathering data through measurements and observations during experiments.
- Analysis: Interpreting data to identify patterns, trends, and relationships.
- Conclusion: Drawing conclusions based on the analysis to support or reject the hypothesis.

6. (a) Justify each of the following statements:
(i) It is advisable to use an evaporating dish instead of a conical flask to evaporate a solution.

Answer: Evaporating dishes have a wide surface area, allowing faster evaporation of liquids compared to the narrow neck of a conical flask.

(ii) In filtration, the filtrate passes through the filter paper while the residue does not.
Answer: Filter paper has microscopic pores that allow smaller liquid particles (filtrate) to pass through while trapping larger solid particles (residue).

(iii) Melting of ice is regarded as a physical change.
Answer: Melting does not change the chemical composition of water; it only changes its state from solid to liquid.

(iv) Rusting of iron is regarded as a chemical change.
Answer: Rusting involves the formation of new substances (iron oxide) through a chemical reaction between iron, oxygen, and water.

(v) Carbon is a non-metal.
Answer: Carbon does not exhibit metallic properties such as conductivity and malleability; instead, it forms covalent bonds, typical of non-metals.

(b) A solution of sugar is said to be a mixture. Justify the statement using four points.
Answer:
- The components (sugar and water) retain their properties.
- The composition can vary depending on the amount of sugar and water mixed.
- Sugar can be separated from water through evaporation or crystallization.
- The solution does not involve a chemical reaction, only physical mixing.

7. (a) (i) Why is it not advisable to examine a car battery using a burning candle light?

Answer:
Examining a car battery with a burning candle is unsafe because:
- Car batteries contain sulfuric acid, which reacts with the lead electrodes to produce hydrogen gas during charging or discharging.
- Hydrogen gas is highly flammable and can ignite when exposed to an open flame, such as a candle, causing an explosion.
- The flame can also cause thermal damage to the battery components, leading to a potential release of acid, which can be hazardous to the skin and eyes.

Thus, it is always recommended to use non-flammable light sources, such as a flashlight, when examining car batteries.

(ii) Why does the blue color disappear during electrolysis of copper(II) sulphate solutions using a carbon electrode?

Answer: The blue color of copper(II) sulfate solution is due to the presence of copper(II) ions (Cu^{2+}) in the solution. During electrolysis:

- Copper(II) ions are reduced at the cathode, depositing copper metal:

$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

- As copper(II) ions are removed from the solution, their concentration decreases, leading to the fading and eventual disappearance of the blue color.

(iii) Why is concentrated sulfuric acid not an electrolyte?

Answer:

Concentrated sulfuric acid is not considered an electrolyte because:

- Electrolytes conduct electricity by dissociating into ions in a solution.
- Concentrated sulfuric acid contains very few water molecules and primarily consists of H_2SO_4 molecules.
- In the absence of sufficient water, ionization of H_2SO_4 to produce H^+ and SO_4^{2-} ions is minimal, resulting in poor conductivity.

However, when diluted with water, sulfuric acid becomes a strong electrolyte due to significant ionization.

(b) With the aid of ionic equations at the anode and cathode, explain the difference between the electrolysis of dilute NaCl using a carbon electrode and molten NaCl.

Answer:

Electrolysis of dilute NaCl (using carbon electrode):

In aqueous NaCl, both Na^+ and Cl^- ions are present, along with H^+ and OH^- ions from water. The reactions are: At the cathode: Hydrogen gas is produced as H^+ ions are reduced preferentially over Na^+ ions.

$2H^+(aq) + 2e^- \rightarrow H_2(g)$

At the anode: Chlorine gas is produced as Cl^- ions are oxidized.

$2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

Electrolysis of molten NaCl (using carbon electrode):

In molten NaCl, only Na^+ and Cl^- ions are present. The reactions are:

At the cathode: Sodium metal is produced as Na^+ ions are reduced.

$Na^+(l) + e^- \rightarrow Na(s)$

At the anode: Chlorine gas is produced as Cl^- ions are oxidized.

$2Cl^-(l) \rightarrow Cl_2(g) + 2e^-$

Key difference: In dilute NaCl, hydrogen gas is produced at the cathode due to the presence of water, while in molten NaCl, sodium metal is deposited.

8. (a) With examples, explain the given terms as used in chemistry:

(i) Fire extinguisher:

Answer:
A fire extinguisher is a device designed to extinguish fires by removing one or more components of the fire triangle (fuel, oxygen, heat).
Example: A carbon dioxide fire extinguisher displaces oxygen and cools the fire.
Example: A foam fire extinguisher forms a barrier over flammable liquids, cutting off oxygen.

(ii) Combustible material:
Answer:
Combustible material refers to any substance that can burn in the presence of oxygen, releasing heat and light.
Example: Wood, paper, and natural gas are common combustible materials. Example:
Diesel is a combustible liquid often used as fuel.

(b) Identify four stages of extinguishing fire using a carbon dioxide extinguisher.

Answer:
Stage 1: Activation: The extinguisher is activated by removing the safety pin and pressing the handle. Stage 2: Displacement of oxygen: Carbon dioxide is discharged, replacing the oxygen around the fire, preventing further combustion.
Stage 3: Cooling effect: The released CO_2 is extremely cold, helping to lower the temperature of the burning material.
Stage 4: Smothering the fire: CO_2 forms a dense layer around the fire, effectively cutting off the supply of oxygen, which is essential for combustion.

(c) Suggest the three components needed to start a fire.

Answer:
A fire requires the following three components, collectively known as the fire triangle:
Fuel: A material that can burn, such as wood, paper, or gasoline.
Oxygen: Present in the air, it supports the combustion process. Heat:
Sufficient energy to ignite the fuel and sustain the fire.

Removing any of these components will extinguish the fire.

9. You paid a visit to a certain village which has a scarcity of cooking fuel but plenty of raw materials for generating biogas. How would you advise the villagers with regard to the given aspects?

(a) Nature of the gas.
Answer:
Biogas is a clean, renewable, and sustainable energy source primarily composed of methane (CH_4) and carbon dioxide (CO_2), with small traces of hydrogen sulfide (H_2S). Methane is the component that makes the gas flammable and suitable for cooking. Biogas is produced through the anaerobic digestion of organic

materials, such as animal waste, plant residues, and food scraps. Unlike conventional fuels like firewood or charcoal, biogas combustion produces minimal greenhouse gases, making it environmentally friendly. Additionally, biogas has no strong odor when processed correctly and burns efficiently without producing smoke, reducing health risks associated with indoor air pollution.

(b) Raw material for generating the gas.
Answer:
Biogas production relies on organic waste materials that decompose naturally. These include:
i. Animal waste: Cow dung, pig manure, and poultry droppings are ideal for biogas generation.
ii. Crop residues: Leftover plant materials from farming, such as maize stalks and sugarcane bagasse.
iii. Food waste: Kitchen scraps, spoiled food, and leftovers from households and markets.
iv. Sewage: Human excreta and wastewater from households can also be processed.
These materials are abundant in rural areas and ensure a consistent supply for biogas production while reducing waste accumulation.

(c) The process involved in generating the gas.
Answer:
i. Collection of raw materials: Organic waste is collected and mixed with water to create a slurry, which ensures the material is easily digestible by bacteria. ii. Feeding into a digester: The slurry is introduced into an airtight biogas digester, where anaerobic bacteria (those that thrive in the absence of oxygen) break down the organic matter. iii. Anaerobic digestion: The bacteria convert the waste into methane (CH_4), carbon dioxide (CO_2), and trace gases during this stage. iv. Gas collection: The generated biogas accumulates at the top of the digester and is piped to storage tanks or directly to stoves.
v. Utilization: The gas is used as cooking fuel, while the leftover slurry (called digestate) is removed and used as a nutrient-rich organic fertilizer.

(d) Three advantages of using biogas over charcoal.
Answer:
i. Environmental benefits: Biogas production reduces deforestation as no trees are cut for fuel. Additionally, methane, a potent greenhouse gas, is captured and utilized instead of being released into the atmosphere.
ii. Economic savings: Biogas systems use readily available waste materials, lowering household expenses on fuel. The by-product (digestate) can also replace chemical fertilizers, further reducing costs.
iii. Health improvement: Biogas burns cleanly without producing smoke or particulate matter, minimizing respiratory diseases and eye irritation common with charcoal use.

10. Illustrate five environmental destructions caused by the process of extraction of metals and suggest five intervention measures to control the problem.

Answer:

Environmental destructions:
i. Deforestation: Mining operations often require the clearing of large forested areas, leading to the loss of trees and vegetation. This results in habitat destruction for wildlife, increased soil erosion, and a reduction

in carbon sequestration. ii. Soil degradation: The removal of topsoil during mining strips the land of its nutrients, rendering it infertile and unsuitable for agriculture or vegetation.
iii. Water pollution: Mining processes release toxic chemicals like cyanide and mercury into nearby water sources, contaminating drinking water and harming aquatic life. iv. Air pollution: Dust and toxic gases emitted during mining operations degrade air quality, leading to respiratory problems for nearby communities and contributing to global warming.
v. Loss of biodiversity: The destruction of ecosystems caused by mining disrupts the balance of flora and fauna, leading to the extinction of certain species.

Intervention measures:
i. Reforestation: Replanting trees in areas affected by mining helps restore ecosystems, reduce soil erosion, and improve biodiversity. ii. Use of eco-friendly mining technologies: Adopting methods such as bio-mining and recycling metals minimizes environmental impact. iii. Strict regulation enforcement: Governments should implement and enforce laws to control illegal mining and ensure companies follow sustainable practices. iv. Waste management: Proper treatment and disposal of mining waste can prevent soil and water pollution. For example, tailing dams can safely contain toxic mining by-products.
v. Community involvement and education: Local communities should be educated on the long-term consequences of unsustainable mining and involved in decision-making processes for better conservation practices.

11. Using five points, explain the harmful effects of terrestrial pollution.

Answer:
i. Soil contamination: Terrestrial pollution, such as the dumping of industrial chemicals and pesticides, contaminates the soil. This reduces soil fertility and affects crop production, endangering food security for communities reliant on agriculture.
ii. Habitat destruction: Landfills, mining, and construction activities destroy natural habitats, leading to the displacement or extinction of wildlife. This disrupts ecosystems and reduces biodiversity.
iii. Groundwater pollution: Hazardous substances from landfills and industrial sites seep into the ground, contaminating underground water supplies. This makes water unsafe for human consumption and agricultural use.
iv. Increased health risks: Exposure to polluted soil can lead to skin irritation, respiratory problems, and diseases caused by toxic chemicals. Poor waste management also promotes the breeding of disease-carrying pests such as rodents and mosquitoes.
v. Land degradation: The accumulation of solid waste, deforestation, and unregulated urbanization renders the land unfit for agriculture, settlement, or recreational use, leading to economic losses and environmental degradation.