CBC

SYLLABUS – ALIGNED CHEMISTRY

ORDINARY LEVEL (SENIOR 1 – 4)

SECOND EDITION
FEBRUARY 2025

UNIQUENESS OF SECOND EDITION

- ✓ *More than 95% formative assessments are detailed at the end of each topic in terms of items applicable to section A, section B or both. All items have been aligned with basis of assessments as per guidance of elements of construct.*

- ✓ Well re-structured learning outcomes for systematic work arrangement and minimizing overlaps across related topics.

- ✓ Scientific investigations are precisely hinted on respective topics.

ADVICE TO FACILITATORS

- ➢ Let's facilitate the WHOLE chemistry, not elements of construct.
- ➢ Assess your learners genuinely before UNEB finally assesses them.
- ➢ Do not omit to facilitate certain topics because their knowledge is relevant in attempting inter-related concepts. *(Inbox me in WhatsApp for more details on this point).*
- ➢ Any "objective" opinion in this publishing is honestly welcomed.

ADVICE TO LEARNERS

- ❖ You should acknowledge that CBC is learner centered, and therefore you are expected to drive more of your learning.
- ❖ Set goals, prioritize tasks, and seek assistance from facilitators for strategic learning and improved academic achievements.

TEXTBOOK MARKETING PAGES

I have considered this topic "Carbon in environment" as a sampling view for any interested client(s) who may want to see how second edition has been structured. ***Plagiarism of this document is highly prohibited.***

THANKS

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CARBON IN THE ENVIRONMENT

Competency: *The learner investigates the diversity of carbon compounds in the environment.*

INTRODUCTION

Carbon is the foundation of life on earth, and its presence is abundant in our environment. Carbon is the basis of all life forms, from simple bacteria to complex organisms like humans and it is the primary component of most fuels and biomolecules like carbohydrates, proteins and fats. The term "*carbon*" originates from the Latin word "carbo," meaning "coal" or "charcoal." Therefore "*Carbon in the environment"* serves as a framework for understanding the relationship between carbon and the environment.

CARBON-BASED FUELS

Carbon-based fuels are energy sources consisting of carbon and hydrogen atoms. Other elements contained may include oxygen and nitrogen. The combination of carbon and hydrogen atoms creates a hydrocarbon molecule which is the basic building block of carbon-based fuels. Carbon-based fuels include; wood, petrol, paraffin, diesel and charcoal as explained in the table below:

Fuel	***How fuel is used***	***Why fuel is used***
Firewood	Burned directly in fireplaces, stoves, or furnaces to produce heat for warmth, cooking or water heating.	- Highly available and accessible. - Has low cost. - Is a renewable resource if sustainably harvested. - Can be used for cooking and heating. - Does not require complex processing.
Charcoal	Burned in stoves, grills, or furnaces to produce heat for cooking, warmth or industrial processes.	- Has high energy density. - Portable and easy to store. - Can be used for cooking and heating. - Can be made from waste wood or biomass. - Has a long shelf life. - Well prepared charcoal does not produce excess smoke or toxic fumes when burned.
Paraffin (Kerosene)	- Burned in lamps, heaters, or stoves to produce light and heat. - Can also be used to provide pain relief to sore joints and muscles through massaging.	- Has high energy density. - Clean-burning and smokeless. - Can be used for lighting, cooking, and heating. - Has a long shelf life. - Does not require complex infrastructure for transportation and storage. - Can be used in aviation and rocket fuel.
Petrol (Gasoline)	Burned in internal combustion engines to power vehicles, generators, and machinery.	- Has high energy density. - Can be used in internal combustion engines for transportation and power generation. - Has a high compression ratio making it suitable for high-compression engines. - Can be blended with other fuels to improve performance.
Diesel	Burned in internal	- Has high energy density.

(Diesel oil/fuel or heavy oil)	combustion diesel engines to power vehicles, generators and machinery.	- Has a high compression ratio, making it efficient for heavy-duty applications. - Can be used in internal combustion engines for transportation, power generation and industrial processes.

Combustion Of Carbon Based-Fuels

In each case above; when the carbon-based fuel is combined with oxygen gas and ignited, energy (in the form of heat and light), carbon dioxide and water vapour are produced.

Carbon-based fuel + Oxygen gas ⟶ Carbon dioxide + Water vapour + Energy.

Impacts Of Burning Carbon-Based Fuels On The Environment:

*Air Pollution**:*** Incomplete burning of carbon-based fuels releases harmful pollutants like carbon monoxide to the atmosphere which contributes to air pollution that result to respiratory problems such as cardiovascular diseases in humans. *Mitigation*: Implement emission controls like scrubbers, electrostatic precipitators and fabric filters in industries to filter out pollutants.

*Climate Change**:*** Burning carbon-based fuels releases carbon dioxide, a greenhouse gas that contributes to global warming hence resulting to changes in climate such as drought. *Mitigation*: Transition to renewable energy sources like solar, wind, or hydro power.

Acid Rain: Burning carbon-based fuels releases carbon dioxide which combines with water to form weak carbonic acid rain which damages infrastructure. *Mitigation*: Switch to cleaner fuels like natural gas.

Land Degradation: Extracting and processing carbon-based fuels such as wood and charcoal can lead to habitat destruction and soil erosion due to deforestation. *Mitigation*: Restore degraded lands through reclamation and reforestation.

FUEL SUSTAINABILITY

Fuel sustainability refers to the ability of a fuel source to meet the energy demands of the present population without compromising the ability of future generations to meet their own energy demands. For example a forest where trees are harvested for firewood should grow more new trees to replace the cut ones thus ensuring a sustainable supply of fuel.

Carbon-based fuels can be renewable or non-renewable. ***Renewable fuel*** is a fuel that can be replenished naturally over human lifetime typically from natural resources. Examples are firewood (wood pellets) and charcoal (made from sustainable wood sources.) ***Non-renewable fuel*** is a fuel that cannot be replenished naturally over human lifetime, typically from finite resources like fossil fuels. Examples are petrol, diesel and paraffin.

Ways to make fuel use more sustainable:

- Improve vehicle fuel efficiency and implement fuel-saving measures like using public transport.
- Switch from fossil fuels to renewable fuels like biofuels or electricity, and blend fossil fuels with renewable fuels to reduce emissions and over-dependence on fossil fuels.
- Ensure sustainable production and harvesting practices for renewable fuel sources like wood, and promote sustainable land use practices for biofuel crops like millet.
- Promote alternative energy sources like solar, wind or hydro power to reduce dependence on non-renewable fuels.

CHARCOAL MAKING

Charcoal is a lightweight, black carbon residue produced by heating wood or other organic materials in the absence of oxygen by a process known as pyrolysis. Charcoal can be inform of lumps or modified briquettes.

a) <u>Primitive Making Of Lump Charcoal From Wood:</u>

Materials: Tree (preferably hardwoods like oak, maple or beech)**,** dry small wood pieces, dry and fresh grass, and cutting equipment such as axe or machines.

Procedure:
- Select and fell tree(s), then split them into small and manageable logs using the axe and panga.
- If necessary, dry wood pieces under strong sunshine for 2 hours to reduce moisture content.
- Using a hoe and spade, dig ankle depth-rectangular pit of desired measurements.
- Place 2 same sized big logs on either length side of the pit.
- Along the width side of the pit, alternatively pack the logs with some few dry wood pieces upto the desired height.
- Cover the wood logs with fresh grass and enough soil while leaving one side open.
- Pack dry grass and other small dry wood pieces in the bottom opening created and lighten them using a match box. As soon as the so wood logs catch fire, enclose the opening with enough soil.
- Leave the wood logs to burn for an average of 2-3 days depending on wood size.
- Remove the charcoal from the pit, cool, sieve, and pack in sacks for storage, use or sale.

Risks and mitigations:
- Wear heat-resistant gloves when cooling hot charcoal to prevent burns.
- Handle an axe and panga with care to prevent the risk of cuts that can result to bleeding.
- Wear safety goggles when cutting wood to protect eyes from harm of flying wood debris.

Note: *Shifting from lump charcoal to charcoal briquettes is necessary for consistent burning, easier combustion, reduced smoke release, and improved heat control, resulting in a more efficient, convenient, and environmentally friendly method in terms of reduced deforestation.*

b) <u>Primitive Making Of Charcoal Briquettes From Waste Organic Materials:</u>

Charcoal briquette is a kind of fuel made from charcoal powder. Compared with traditional fuels, charcoal briquettes can not only generate heat continuously but also produce no smoke and odour during combustion.

Materials: Sawdust, charcoal dust, white ash, starch**,** water**,** blender**,** a briquette machine**,** a drying rack.

Procedure:
- Sieve charcoal dust to free it from any impurity such as metals.
- Crush and mill the charcoal dust into a fine powder.
- Mix the charcoal powder with white ash, saw dust, starch and add moderate amount of water to create a uniform blend.
- Pick a sizeable blend and roll between the palms of your hands. (Or use a briquette machine to shape the blend into briquettes.)
- Dry the briquettes under moderate sun shine (or use a drying rack) to remove excess moisture.
- Allow the briquettes to cure for several hours or days to harden.

Risks and mitigations:
- Wear protective masks and gloves, and implement dust suppression systems to reduce the inhalation of dust and particles.

<u>The Chemistry Behind Burning Organic Material In a Limited Supply Of Oxygen Gas:</u>

When organic material burns in a limited supply of oxygen gas it undergoes a process called pyrolysis or carbonization. This process breaks down the material into simpler molecules releasing water vapour and carbon monoxide. The remaining carbon-rich material then

decomposes into volatile compounds such as methane and hydrogen. It also produces a liquid mixture of hydrocarbons known as tar and a final solid residue called charcoal.

Word Equation:

Wood + Limited oxygen gas $\xrightarrow{\text{Heat}}$ Charcoal + Water + Carbon monoxide + Hydrocarbons.

CARBON DIOXIDE GAS

Carbon dioxide is a covalent acidic compound with a molecular formula of CO_2 consisting of carbon and oxygen atoms arranged in a linear structure. Carbon dioxide is a gas that extinguishes a lighted splint with a distinctive "hissing" sound. Carbon dioxide is naturally present in the earth's atmosphere at a concentration of 0.03% of air. Carbon dioxide can also be released through human activities like fossil fuel combustion and can be found in volcanic gases and ocean water.

Chemical equation of carbon dioxide production:

Limestone (Calcium carbonate) + Dilute hydrochloric acid. $\longrightarrow$ Calcium chloride + Carbon dioxide + Water.

$CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$

Physical Properties And Uses Of Carbon dioxide:

Carbon dioxide's *colourless, tasteless, and odourless* properties make it an ideal preservative in the food and beverage industry, as it does not affect the flavour or aroma of food. This is particularly useful in the preservation of fruits, vegetables, and meats, where maintaining natural flavor and texture is crucial.

Carbon dioxide's *moderate solubility in water* makes it a useful preservative in carbonated beverages such as soda. When dissolved in water, carbon dioxide forms carbonic acid which acts as a natural preservative to inhibit the growth of bacteria and other microorganisms. This helps maintain the quality and freshness of carbonated beverages.

Carbon dioxide's *non-flammable properties* make it a safe and effective fire extinguishing agent. Since carbon dioxide neither burns nor supports burning, it can be used to choke fires particularly in electrical and chemical fires, where water or foam extinguishers may not be effective.

Carbon dioxide's *ability to freeze into white dry ice* makes it a useful tool for preserving perishable items such as fish and meat. Dry ice is extremely cold, with a temperature of -78.5°C, making it ideal for rapid cooling and preservation. By packing dry ice with perishable items, individuals can maintain a consistent refrigerated temperature during transportation or storage, ensuring the quality and safety of the food.

Carbon dioxide being *heavier/denser than air* allows it to displace oxygen in confined spaces, making it useful for fire suppression. When released in an enclosed area, carbon dioxide can quickly displace oxygen hence suppressing the fire which oxygen needs to keep burning. This property makes carbon dioxide an effective fire suppression agent in areas such as data centers, laboratories, and industrial facilities.

Impacts Of Carbon dioxide On Climate:

Climate refers to the long-term average atmospheric conditions in a particular region or globally, including temperature, humidity, cloudiness, wind patterns and precipitation.

Carbon dioxide has a significant impact on the climate: It traps heat, leading to a rise in global temperatures. This warming effect also causes glaciers and ice sheets to melt, contributing to sea-level rise. Additionally, carbon dioxide alters weather patterns, resulting in more frequent and severe heatwaves, droughts, and storms, which can have devastating effects on ecosystems and human societies. Furthermore, when carbon dioxide is absorbed by oceans, it causes acidification which eventually harms marine life particularly coral reefs and shellfish.

GREENHOUSE GASES (GHGs)

Greenhouse gases are gases that trap heat in the earth's atmosphere, leading to global warming (long term rise in the average surface temperature of the earth). Examples of GHGs include; carbon dioxide, methane, nitrous oxides, ozone and fluorinated gases.

The sources of greenhouse gases can be broadly categorized into human activities and natural sources. Human activities such as burning fossil fuels for energy and transportation, deforestation for land use, agriculture, and industrial processes release significant amounts of greenhouse gases that include: carbon dioxide, methane, and nitrous oxide. On the other hand; natural sources including volcanic eruptions, wildfires, and the release of gases from oceans, also contribute to greenhouse gas emissions.

Ways Greenhouse Gases Can Affect The Climate:

Greenhouse gases trap heat in the atmosphere, leading to global warming. This happens when gases such as carbon dioxide and methane absorb infrared radiation from the Earth's surface, preventing it from escaping into space. As a result, the earth's temperature rises, causing melting of polar ice caps, glaciers, and sea-level rise. To mitigate this effect, individuals can reduce their carbon footprint by using public transport, carpooling, or driving electric or hybrid vehicles.

Greenhouse gases alter global precipitation patterns, leading to more frequent and severe droughts and floods. This occurs when warmer temperatures evaporate more water from the oceans, leading to intense rainfall events. To mitigate this effect, communities can implement sustainable water management practices, such as conserving water, building flood-resistant infrastructure, and promoting climate-resilient agriculture.

Greenhouse gases accelerate ocean acidification which causes harm to marine ecosystems and biodiversity. This happens when carbon dioxide dissolves in seawater forming carbonic acid and reducing the pH levels. As a result, marine organisms especially coral reefs and shellfish struggle to build their shells and skeletons hence leading to declining populations. To mitigate this effect, governments and organizations can establish marine protected areas, promote sustainable fishing practices, and support research and development of technologies that help remove carbon dioxide from the atmosphere.

Why air pollution is a global problem*?*

This is because greenhouse gases exceeds national borders and affects the entire planet, causing widespread harm to human health and the environment. Pollutants emitted in one region can travel massive distances, impacting air quality and environmental conditions in other areas hence making it a collective issue that requires international cooperation.

ATMOSPHERE AND OCEAN WARMING

a) Atmospheric Warming:

When the sun's rays enter the earth's atmosphere, they warm the surface. This warmth is then released into the air as infrared radiation. Carbon dioxide molecules in the atmosphere absorb, trap and prevent the radiation from escaping into space. (It's likened to a blanket that keeps you warm – Carbon dioxide acts like a blanket, wrapping the earth in warmth). As more carbon dioxide molecules absorb and retain heat, the atmosphere warms even more. This creates a cycle where the atmosphere gets warmer and warmer leading to global warming.

b) Oceanic Warming:

When the warm atmosphere transfers its heat to the ocean's surface, it causes the ocean's water to warm and expand. The warm water is then carried by ocean currents to other parts of the ocean. This process continues gradually eventually contributing to oceanic warming. Additionally; the

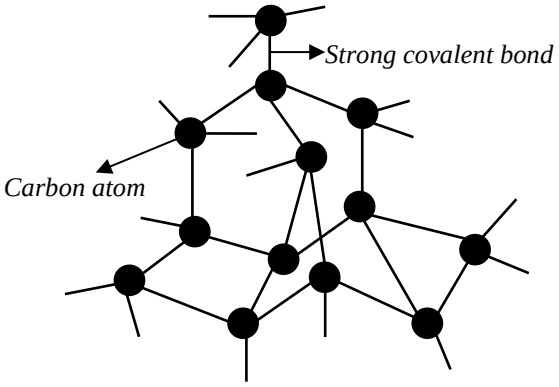
ocean's deep waters absorb heat from the surface and store it for long periods. This means that even if the atmosphere cools slightly, the ocean's stored heat can still contribute to warming. It's likened to a slow-cooker – the ocean absorbs and stores heat, releasing it over time to warm the ocean.

ALLOTROPY

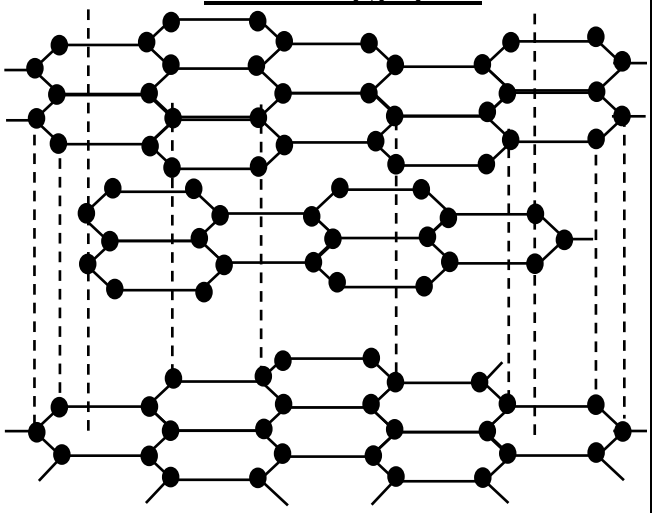
Allotropy refers to the existence of two or more different physical forms of the same element with the same atomic number but differ in their atomic arrangement. These different forms are called allotropes. Allotropes are different physical forms of the same element, which can exhibit varying physical and chemical properties. Carbon allotropes include diamond and graphite.

The Giant Covalent Structures Of Diamond And Graphite As Allotropes Of Carbon:

Structure of diamond



Structure of graphite



How The Properties And Uses Of The Allotropes Of Carbon Relate To Their Structural Features:

Properties	***Uses***	***Structural Feature***
	Diamond	
Is the hardest substance.	- Used for making cutting and drilling tools such as diamond-edged saw blades and drill bits that are used for cutting and drilling through hard materials like stone and metal.	Tetrahedral bonding arrangement *(Each carbon atom bonded to four neighboring atoms in a pyramid-like structure)*
Has high density.	- Suitable for radiation shielding for example; protecting against X-rays and gamma rays.	High atomic packing density *(Tightly packed atoms with minimal space between them)*
Has high thermal conductivity.	- Used for making high-power electronic devices such as heat sinks and thermal management systems.	Strong three-dimensional lattice structure *(Rigid and stable network of atoms bonded together)*
Chemically inert.	- Used for making biomedical implants such as joint replacements and dental implants.	Face-centered cubic lattice *(Atoms arranged in a cubic pattern with one atom at each corner and one in the*

		center)
Optical transparency.	- Used in optical windows like laser windows and spectroscopy applications.	Strong covalent bonds between carbon atoms *(Atoms bonded through shared electrons, forming a robust connection)*
Graphite		
Has soft and slippery texture.	- Makes graphite an excellent lubricant, reducing friction and wear on moving parts in machinery and engines. Also best used for pencil writing.	Hexagonal layered structure *(Atoms arranged in hexagonal rings, stacked in layers which can slide past each other.)*
Low thermal conductivity.	- Used for thermal insulation in fireproof materials and heat shields.	Weak Vander-Waals bonds between layers *(Layers held together by weak intermolecular forces)*
High electrical conductivity.	- Used for making electrodes and electrical contacts like batteries and solar panels.	High in-plane conductivity *(Electrons freely moving within layers)*
Chemically inert.	- Used in electrolysis as an electrode.	Carbon atoms bonded in a flat, two-dimensional arrangement.
Intercalation capability (atoms become inert between layers of a material)	- Used in battery anodes like lithium-ion batteries for energy storage	Layered structure with interlayer spacing *(Space between layers allows for intercalation)*

Carbon Fibers: Carbon fibers are thin, lightweight strands of carbon atoms bonded together in a crystalline structure. They are known for their exceptional strength, stiffness, and resistance to heat and chemicals. Carbon fibers are often used in composite materials, such as carbon fiber reinforced polymers, to create lightweight and durable structures for various applications, including aerospace, sports equipment, and automotive.

Graphene: Graphene is a two-dimensional material composed of a single layer of carbon atoms arranged in a hexagonal lattice structure. It is incredibly thin, flexible, and strong, with exceptional electrical and thermal conductivity. Graphene has numerous potential applications, including electronics, energy storage, and biomedical devices, due to its unique properties, such as high carrier mobility and optical transparency.

Note:

a) Diamond mining poses a significant threat to the environment as it leads to deforestation, soil erosion, and water pollution. The excavation process involves clearing large areas of land, resulting in habitat loss and disruption of ecosystems. To mitigate this, mining companies can implement reforestation programs and adopt more environmentally friendly extraction methods. On the other hand, diamond dust and particles generated during cutting and polishing processes can cause respiratory problems and lung damage in humans. Prolonged exposure to diamond dust can lead to serious health issues, including silicosis. To mitigate this, workers in the diamond industry should wear protective gear, including masks and respirators, and follow proper ventilation procedures.

b) Graphite mining can contaminate soil and water sources with heavy metals, posing a risk to local ecosystems and wildlife. The mining process can also lead to the release of particulate matter, contributing to air pollution. To mitigate this, mining companies can implement proper waste management and rehabilitation programs. Graphite dust can also cause respiratory problems and skin irritation in humans, particularly those working in the mining and manufacturing industries. Prolonged exposure to graphite dust can lead to lung disease and other health issues. To mitigate this, workers should wear protective gear, including masks and gloves, and follow proper ventilation procedures.

WATER HARDNESS

Regardless of *soft water* which lathers with soap and is obtained from rain water; *hard water* refers to the kind of water that contains different levels of dissolved minerals like calcium and magnesium salts. These minerals make water "hard" because they react with soap and other cleaning agents, making it difficult to lather or foam. Hard water does not lather with soap but instead forms a precipitate.

Hard water can manifest in various ways, making everyday life inconvenient. Some common signs of using hard water include: dull and rough linens and clothes, ugly stains on white porcelain, and scale build-up on tap outlets, which can also lead to low water pressure in showers due to clogged pipes. Additionally, hard water can leave behind a chalky, white residue or spots on dishes, and even cause stains to appear in the shower, making cleaning and maintenance a challenge.

How Rainwater (Soft Water) Becomes 'Hard' In Limestone Areas:

As rainwater soaks through limestone, it becomes hard due to a process known as calcification. Limestone (primarily composed of calcium carbonate) reacts with the slightly acidic rainwater which is formed when carbon dioxide from the atmosphere dissolves in water forming calcium hydrogen carbonate that causes water hardness. This process continues as the water flows through the limestone areas thus increasingly hardening it.

$$CaCO_3(s) + H_2O(l) + CO_2(g) \longrightarrow Ca(HCO_3)_2(aq)$$

Types Of Water Hardness:

Temporary hardness (carbonate hardness) occurs when calcium bicarbonate or magnesium bicarbonate are present in water. This type of hardness is called "temporary" because it can be easily removed through boiling. Temporary hard water may include; tap water and well water. *Permanent hardness (non-carbonate hardness)* is caused by the presence of either calcium sulphate or magnesium sulphate in water. Permanent hard water include; groundwater.

Softening Water Hardness:

a) By Boiling: Boiling is simplest and effective method for softening small quantities of temporary hard water. During boiling, the calcium hydrogen carbonate decomposes to form calcium carbonate, water and carbon dioxide. The insoluble calcium carbonate forms scale on the heating element or can be filtered out hence leaving soft water.

Calcium hydrogen carbonate $\longrightarrow$ Calcium carbonate + Water + Carbon dioxide.

$$Ca(HCO_3)_2(aq) \longrightarrow CaCO_3(s) + H_2O(l) + CO_2(g)$$

b) Adding washing soda: Washing soda (sodium carbonate) is used for washing clothes and to soften both temporary and permanent hard water. When washing soda is added to hard water, the carbonate ions react with the magnesium ions and calcium ions to form insoluble carbonates which can then be filtered away.

$$Na_2CO_3(aq) + Ca(HCO_3)_2(aq) \longrightarrow CaCO_3(s) + 2NaHCO_3(aq)$$

$$Na_2CO_3(aq) + MgSO_4(aq) \longrightarrow MgCO_3(s) + Na_2SO_4(aq)$$

c) Distillation: Is a highly effective method for removing permanent and temporary hardness. The process involves vaporizing the water and then condensing it. This leaves behind any minerals that were present in the water. Distillation is highly applied for industrial processes and it seems to be expensive for softening temporary hard water.

$Mg(HCO_3)_2(aq) \longrightarrow MgCO_3(s) + H_2O(l) + CO_2(g)$

$MgSO_4(aq) \longrightarrow MgSO_4(s) + H_2O(l)$

d) Using an ion-exchange column: The column contains a resin packed with sodium ions. It is used to soften both temporary and permanent hard water. As the hard water passes through the column, the sodium ions in the resin are exchanged for the calcium and magnesium ions in the water thus removing them. Two sodium ions are usually needed to replace one calcium or magnesium ion. Eventually when all of the sodium ions have been used up with only magnesium and calcium ions stuck to the resin, the column is recharged with concentrated sodium chloride which flushes out the calcium and magnesium ions and replaces them with sodium ions. This method is used in dishwashers and it is why the dishwasher salt is replaced so often.

How Water Hardness Affects Soap:

Hard water significantly impairs the effectiveness of soap by altering its chemical properties. The high levels of calcium and magnesium ions in hard water react with soap molecules, forming a complex that reduces the soap's ability to lather and clean. This reaction leads to the formation of a sticky, insoluble scum that adheres to skin, hair, and surfaces, making rinsing difficult and requiring more soap to achieve cleanliness. Ultimately, hard water renders soap less effective, increasing soap consumption and leaving behind a residue that can cause skin irritation and dryness.

Scientific Investigations On Hard Water By Titration Method:

Experimental investigations of softening hard water involve to;

a) Determine the volume of softening agent (washing soda/sodium carbonate) required to soften volume of hard water. *Permanent white precipitate formed is the end point of titration.*

b) Determine the best alternative from various sources of hard water by determining the ease of lather formation when hard water is titrated with soap solution. *Permanent lather formed is the end point of titration.*

Experiment a): Peter Lotukei wants to start a laundry shop in Moroto. There are rumours of various hard water sources available in his neighborhood. To maximize profits, he wants to experiment and recommend himself the most suitable water source among the two water sources near him. Peter fetched the water from each of the sources without mixing any of them. Although he knows that soft water easily forms lather with soap solution, he failed to obtain the right amount of soap solution in correspondence to his prediction of utilizing $200dm^3$ of water each day. He finally resolved to consult your chemistry facilitator who has tasked you with helping Peter to achieve his target.

You are provided with;
- Water samples P and Q.
- JA1 soap solution.
- Other laboratory apparatus.

Facilitator's preparations for each learner/group:
P = 100mL of distilled water containing 0.01g of salt.
Q = 100mL of distilled water containing 5g of salt.
Freshly prepared 100mL of JA1 soap solution, and materials in the procedure.

Task: Plan and design a scientific investigation to simplify Peter's choice.

Proposed response: ***(Fill your experimental results where you get dashes)***

Aim: An experiment to determine which of the two water samples P and Q easily forms lather with soap solution.

Hypothesis: Soft water easily forms permanent lather with soap solution.

Variables:
Independent variable: Hardness of water samples.
Dependent variable: Volume of JA1 soap solution.
Controlled variables: Volumes of P and Q, and concentration of soap solution.

Procedure:
a) Using a 20mL pipette, 20mL of water sample P was pipetted into a 250mLclean conical flask.
b) The 50mL burette was filled with JA1 soap solution via a filter funnel and adjusted to the zero mark.
c) The water in the 250ml conical flask was titrated with JA1 soap solution from the burette while gently shaking until permanent lather is formed.
d) The final burette volume for JA1 soap solution used to form permanent lather was noted and recorded.
e) The resultant mixture was poured into the sink, the conical flask rewashed.
f) The procedures a) to e) were repeated for more two trials.
g) The procedure a) to f) were repeated for water sample Q instead of P.

Risks and mitigations:
Body cuts due to breaking of the burette. This can be mitigated by carefully and gently using the burette.

Data recording and presentation: *(Fill in your experimental results in 2 decimal places)*
Table of results;
Volume of P and Q pipetted = 20.0mL

Water sample	P			Q		
Final burette reading (mL)						
Initial burette reading (mL)						
Volume of JA1 soap solution (mL)						

Data analysis and interpretation:
The average volume of two titre values of JA1 soap solution;
P ……...
Q ……..

Then calculate the amount of soap solution required on daily basis for the chosen water sample:
……
……
……
……
……
……
……
……

Conclusion: Water sample …….. requires …….mL of JA1 soap solution to easily form permanent lather than water sample…….which requires much soap. Therefore peter shall use ……..dm^3 of soap solution on daily basis.

Recommendation: I recommend Peter to use water sample.…… for his laundry shop business.

Experiment b): Sarah, a laundry worker is facing a pressing issue of stubborn spots on her customers' clothes that remain after washing thus threatening her livelihood. Her boy-friend, Daniel suggests adding washing soda to the water, but Sarah is uncertain about the correct dosage. With a daily usage of 300 liters of water, Sarah needs guidance on how much washing soda to add to effectively soften the water and prevent mineral deposits which react with the washing soda according to the equation:

$MgSO_4(aq) + Na_2CO_3\ (aq) \longrightarrow MgCO_3(s) + Na_2SO_4(aq)$.

Daniel is challenged with Sarah's concern. You have been contacted for help.

You are provided with;
- KA1: Washing soda.
- KA2: Hard water.
- Other laboratory apparatus.

Facilitator's preparations for each learner/group:
KA1 = 150mL of 0.5M of washing soda (sodium carbonate).
KA2 = 150mL of 1M of magnesium sulphate solution.
Materials in the procedure.

Task: Plan and design a scientific investigation to guide Sarah.

Proposed response: ***(Fill your experimental results where you get dashes)***

Aim: An experiment to investigate the volume of KA1 required to soften 300 liters of KA2 used.

Hypothesis: ……. liters of KA1 solution is required to soften 300 liters of KA2 used daily.

Variables:

Independent Variable: Volume of KA2 measured.

Dependent variable: Volume of KA1 solution added.

Controlled variable: Water hardness of KA2.

Procedure:

a) Solution KA1 was filled into a burette via a filter funnel and adjusted to the zero mark.
b) Using a 100mL measuring cylinder, 25mL of KA2 was measured and transferred into a 250mL clean conical flask.
c) KA1 solution was run into KA2 in a conical flask while shaking gently until a white precipitate forms.
d) The final burette reading was noted and recorded.
e) The content in the conical flask was poured into the sink and conical flask rewashed.
f) The procedures a) to e) above were repeated for (30, 35, 40, 45 and 50)mL of KA2 solution.

Risks and Mitigations: Handle delicate glass ware such as conical flask with care to prevent breakage which may result to body cuts hence loss of blood.

Data recording and presentation: *(Fill in your experimental results in 2 decimal places).*

Volume of KA2 (mL)	25	30	35	40	45	50
Final burette reading (mL)						
Initial burette reading (mL)						
Volume of KA1 used (mL)						

*Expected Trend***:** Increase of volume of hard water increases the volume of KA1 used.

Plot a graph of volume of KA1 solution against volume of KA2 *(Obtain a linear graph with the line of the best fit).*

Data analysis: Calculate the gradient/slope of the graph and express in ratio form to make comparison of KA1:KA2 solutions. Involve 300L of KA2 used daily to determine the corresponding volume of KA1.

……
……
……
……
……

Conclusion: ……liters of KA1 is required to soften ……liters of KA2 on daily basis.

Recommendation: I recommend Sarah to be adding……liters of KA1 solution to …….liters of KA2 so as to avoid stubborn spots on her customers' clothes.

ACTIVITY OF INTEGRATION 7

The increasing population around Lake Victoria is facing a fuel environmental crisis. To meet the increasing demand for energy, residents have turned to wood fuel, leading to widespread deforestation and its consequences. The residents are now under pressure to address their mistake but lacks knowledge about sustainable substitutes of diversity of carbon compounds in their environment. Their leader has contacted the town council for rescue.

The town council has selected you to make a write up that can be used on the sensitisation workshop already planned to take place.

Task: As a chemistry learner, complete the duty you have been assigned.

ASSESSMENT 7

SECTION A

1. Weddings are so valuable for legal marriages. Of recent in Matany Town Council, Daniel wedded Lydia and the ring used for strengthening the covenant was made from the hardest and most durable natural substance that is composed of element J. In other words, the substance is just another form of J. Lydia over asked Daniel about the substance but she received no clear response. Although Daniel only managed to tell her that the substance has a pyramid-like structure, she was not contented. To address the situation, Daniel has decided to contact you for enhanced information. *(J has neutrons = protons = 6)*

Task: As a chemistry learner;

a) Advice on the type of the ion of the substance.

b) Clearly explain how four properties and uses of the substance relate to its structural features.

c) Assist on clarify on the harmful consequences of the substance to the environment.

2. In Kampala-Uganda, soft drinks-producing companies relies on a carbon compound to produce their popular carbonated drinks. At the factory, the carbon compound stored in cylinders is mixed with distilled water from Lake Victoria, natural flavors and preservatives sourced from farms are also added. Apart from atmospheric source, the carbon compound can be obtained when limestone is reacted with dilute hydrochloric acid. The residents of Lake Victoria shores are complaining about the greenhouse gas produced by the reaction. Apart from the benefits gained from the carbon compound, the residents wants to understand more of it. Their leader has come to you for written clarification.

Task: Accomplish the following;

a) Guide on the category of the compound and write chemical equation of its production.

b) Explain the properties of the compound. Detail on its alternative benefit.

c) Justify how the carbon compound is a greenhouse gas agent in relation to climate?

d) Air pollution is a global problem? Oceanic and atmospheric warming is also being caused by the compound. Clarify all these concerns.

3. Sarah Lomala was so happy when her mother Lokorio Lina bought for her a pencil for accomplishing her drawings. It seemed to be an Hp-pencil. After sharpening the pencil, Lina was so excited to see a black mineral. It's believed that the mineral is an alternative of T in the periodic table. Besides this, Lina asked Sarah for more clarification.

E	

					K
	T				
				O	

Sarah only stated that the mineral has hexagonal layered structure. Because Lina is not contented with the information mentioned, Sarah has come to you to seek further details about the mineral.
Task: Being a chemistry learner;
a) Inform Sarah about the category of the mineral.
b) Clearly explain how four properties and uses of the mineral relate to its structural features.
c) Advice on implications of the mineral to the environment. *(Include on how to mitigate.)*
d) Evaluate T in addition to E, K, and O using a binary key. *(Use basis of the periodic table)*

4. The use of traditional fuels has currently reduced steeply due to strict laws against deforestation. Utmost major three fuel-fractions from fractional distillation of crude oil are now taking the lead in both internal and international markets. It's known that the fuels majorly contain carbon and are termed as "petroleum fuel-products." The communities are very curious on how beneficial the fractions are? The more questions brought have overwhelmed the area leader. To save time of over-thinking, she has come to you for detailed information.
Task: By means of being a positive contributor to the society;
a) Guide on the category of the fractions.
b) Give advice on how and why the exemplified fraction is used. Notify on fractions' sustainability.
c) How does combustion of the fractions impact the environment? *(Support your response with an equation)*

5. Most residents in Lorengedwat sub-county cut down natural fuel for various reasons including cooking. The most common reason realized is that of obtaining a more efficient fuel which does not produce excess smoke when ignited. The fuel can be prepared in average of three days. Because of its goodness, a majority of the residents wants to understand how the previous fuel can be transformed. They also want to understand more of the fuel-produced. The area leader has contacted you for details required.



Task: As a chemistry learner;
a) Guide on the general type of the fuels discussed. Briefly describe how each fuel is used.
b) i) Coherently and briefly explain how efficient fuel mentioned can be obtained. Comment on the chemistry behind burning organic material in a limited supply of oxygen gas. *(Support your response with an equation)*
ii) Why do the residents prefer the transformed fuel? Give a remark on its sustainability.
c) i) In what manner does the transformed fuel affect the environment?
ii) The residents are complaining that the fuel produced can still yield smoke when burning and takes short time to burn completely; they are therefore inquisitive on how it can be blended with organic waste to produce the same fuel with consistent burning and reduced/no smoke released. Help them.

SECTION B *(Carbon-based fuels (firewood and charcoal) sourced from forests)*
6. In central Uganda, charcoal producers' harvests trees from forests thus fueling deforestation. They also over-graze their cattle in the available vegetation. This has reduced biodiversity and other consequences. The quality of the fuel resource is now affected severely. To harmonize the situation, a sensitisation workshop has been organised to create awareness to the communities.
Task: As a chemistry learner, prepare a write up that can be used upon the meeting

7. In Uganda's Mabira Forest, some trees have been cleared for agricultural land and other purposes. The habitat of endangered species like the grey-cheeked parrot and the blue monkey has been threatened. Even the water cycles that supplies communities with water have been disrupted. This has resulted to changes in weather patterns.

The communities are complaining of their impactful activity to their natural resource. They need guidance. A sensitisation workshop has been organised. You have been invited to come with a write up to be used upon the meeting.

Task: Being a concerned environmental conserver, make a write up to be used upon the meeting.

8. Forests are of great impact to our communities. In a certain community, some illegal hunters regularly burn grass in the forests in search for animals. Most habitats have been destroyed and wildlife being forced to flee. Nearby residents' gardens are also yielding less than expected. The community has developed a negative attitude towards the consequences caused. The community members have reported their concern to the respective authority.

A sensitisation meeting has been organised to educate details about the challenge recognised. You have also been invited.

Task: As a learner of chemistry, make a detailed write up to comprehend the community's concerns.

END

"If we become TOO tied up in elements of construct ONLY, then we shall find chemistry in place of an art subject. And some learning outcomes will be redundant."

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