GRAND O'LEVEL CHEMISTRY SEMINAR AT ST. JOSEPH'S S.S.S NAGGALAMA

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CHEMISTRY; PAPER 1; 545/1

SAMPLE TEST ITEMS

SECTION A

1. APPLICATION OF CHEMISTRY IN DAILY LIFE

(Food additives, Drugs and medicines, Nuclear processes, Soapy and soapless detergents)

ITEM 1 (i)

On a wedding party guests were wondering and excited by the aroma and taste of the food served, that it so delicious.



The Master of Ceremony (MC) kept on notifying the people that the food had been prepared with knowledge of chemistry and some of the guests wanted to know what the Master of Ceremony meant

Task

As a chemistry learner, basing on the MC's communication advise the guests on:
(a) The variety of the ingredients used.
(b) The suitability of the ingredients
(c) The possible problems associated with, and choice of the ingredients used.

ITEM 1 (ii)

In one of the societies in Kampala, there is an outbreak of bacterial diseases such as typhoid. The society members rely on each other for medical advice. Recently, a resident complained about persistent stomach ache followed by diarrhoea, but there was no one to advise on proper medication the society members should use.

Task:

As a learner of chemistry;

(a) Advise society members on the possible types of products to use?
(b) Carefully educate them on what the products exactly do.
(c) Advise them on the challenges associated with the product use and consequently how to select the products to use

ITEM 1 (iii)

In one of the towns in Uganda, residents are facing an unexpected challenge of water wasting detergents. The locals are frustrated and do not know what to do. They have been advised to try other alternatives on the market to overcome the challenge but they need more advice on this

As a concerned chemistry student in the town,

Task:

Help the residents,

(a) understand the variety and mode of action of the detergents
(b) on the consequences of the detergent

ITEM 1 (iv):

Due to increasing demand of power in Uganda, the government wants to adopt use of nuclear power.

However, there is little knowledge among the natives about how nuclear energy works. The ministry of energy and mineral development is interested in a knowledgeable person to sensitize the natives about the matter.

Task;

As a chemistry learner,

(a) advise the natives on the types of processes that can be used by the government.
(b) educate them on how the energy can be produced and **caution** them on the possible dangers associated with the process.
(c) suggest to the residents on the most efficient process.

2. DIVERSITY AND INTERACTIONS OF SUBSTANCES AND THEIR IMPORTANCE IN LIFE

(Trends in the periodic table, polymers, periodic table, structure and bonds)

ITEM 2 (i):

A shop attendant wants to use environmentally friendly and sustainable packing materials. He is not having enough information about which packaging materials to use.

He has decided to seek for advice from a person with good knowledge of chemistry.

TASK

a) help him appreciate that the packing materials are of different types
b) advise him on the suitability of the materials

ITEM 2 (ii):

A group of Learners were faced with a unique solid substance, X, which they suspected to be an element. 0.3g of the element could burn in air to form 0.5g of the solid product. One of them picked interest in what could be the chemical formula of the oxide of the element. However, he did not know how to determine the formula. When they contacted the laboratory technician he gave them the atomic number and mass number of X as 12 and 24 respectively, and the symbolic representation of oxygen as $^{16}_{8}O$

As a student of chemistry help the learners to;

(a) understand the nature of substance X
(b) determine the formula of the oxide of X
(c) know the environmental consequences of the element

ITEM 2 (iii):

Charcoal is a common fuel used in many homes in Uganda. During its combustion in excess oxygen supply, it produces carbon dioxide. Your friend is using 80.5g of charcoal to cook food in a busy evening for guests. It burns completely as shown in the equation below.

$C(s) + O_2(g) \longrightarrow CO_2(g)$

Task

As a learner of chemistry

a) Assess the product formed
b) Advise the friend on the appropriateness of the product formed.
c) Calculate the volume of the gas produced every busy evening.
(1 mole of a gas occupies 22.4*l* at s.t.p, C = 12)

Help the friend understand the impact of the product in the environment

ITEM 2 (iv)

A businessman was selling salt mixed with particles of sand, tricking people who couldn't notice the difference between the salt and its mixture with sand. This made it difficult for residents to use the salt. They need your help to prevent future problems and avoid any chemical dangers

They trust your chemistry knowledge to clarify the situation and prevent further suffering.

Task.

Help the residents:

(a) Know the behavior of the substances in the mixture.
(b) Evaluate the problems associated with the use of one of the component in the mixture

ITEM 2 (v):

A group of s.3 learners came across data on melting points of elements whose identities they forgot to capture. They brought it to s.4 learners to help them analyze and interpret the data for them.

Element	X	Y	Z	W	A	Q	M
Atomic number	11	12	13	14	15	16	17
M.P/^{o}C	98	650	660	1410	44	119	-101

As a senior four learner with good knowledge about periodic trends,

(a) help them
  (i) understand the classes of the elements (ii) on how to interpret the data.
(b) suggest to them the possible uses and environmental impact of the elements

SECTION B

PART I: CONTRIBUTION OF CHEMISTRY TO OUR ECONOMY

(Extraction of Copper, iron, aluminium, manufacture of nitric acid, sulphuric acid, fertilizers, ethanol, detergents, sodium hydroxide, chlorine gas, oxygen gas and cement)

ITEM 1 (Cement)

The price of cement in Uganda is so high. However, the people in authority are attributing this to the limited amount of cement in the country because of the few manufacturing industries. A resolution was made to set up another cement factory in your village in Tororo District. The village members are wondering how this will be done. But the chairman has called for a meeting and has requested you to give a talk to the members.
As a chemistry learner,

TASK

Make a write up of your communication to the village members.

ITEM 2 (copper)

Uganda electrical engineer's forum has raised a concern of reduced copper wires in the country.
In response, the government has contracted an investor to set up a new copper extraction plant in Kasese, a copper ore rich district.
Unfortunately, the investor has some doubts on his scientific knowledge on the production process and the likely impact on the environment.

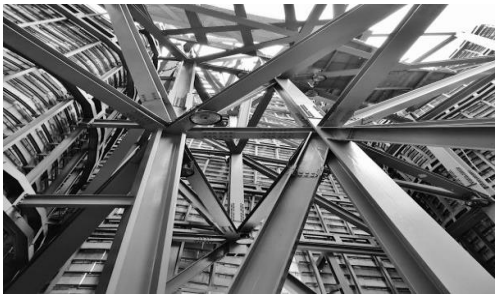
As a chemistry learner,

Task

Write a message to the investor to settle his doubts before his final interaction with residents.

ITEM 3 (iron)

Rushekye hills in Kisoro district Uganda are found to contain significant iron deposits. An investor wants to set up an iron and steel rolling factory to tap into the opportunity. The local leaders are debating about the project. However, they seem not to understand how iron can be obtained from its raw materials and consequently its benefits.



As a SENIOR FOUR candidate with the knowledge of chemistry, the residents are confident that you can provide the necessary information.

TASK

Prepare a presentation which you will use upon invitation.

ITEM 4 (fertilizers)

In Kabarole district most of the citizens survive on farming that involves growing of crops every season. For the last three seasons, farmers are registering a great decrease in the amount of the harvest they are making. The government has cleared a local investor to startup a fertilizer production plant in the district. However, the citizens are very much worried about the effects of the plant to the environment.
The chairperson LC5 of the district has appointed you to sensitize the citizens of the area.

Task

Prepare a presentation you will make during the meeting.

ITEM 5 (chlorine and sodium hydroxide)

At Lake Katwe in Kasese District, Uganda, there are significant rock salt deposits. Discussions are underway in your class regarding the operations of a proposed chlorine plant. Students are unclear about how chlorine is manufactured from raw materials and its advantages.

They need guidance on the production process, emphasizing safety and environmental concerns.

Task

Write down your presentation in the discussion.

ITEM 6(oxygen)

There is high demand of oxygen in referral hospitals in Uganda. An investor was contacted by government to set up an oxygen manufacturing plant at Namanve, one of the swamps near Kampala to tap into the opportunity. However, the residents seem not to understand how the process will occur plus its consequences and are resisting the project.

As a **senior four** candidate with the knowledge of chemistry, you are required to create awareness to the members and provide the necessary information.

TASK

Write a presentation you will use upon meeting them.

Item 7(soapy detergents)

A parent of a senior four candidate in one of the villages in Kaberamaido District belongs to a "women's development group". The members of the group have come up with a project idea of making soap which they think they can sell to the nearby shops and obtain revenue. However, none of the members has knowledge about soap making. But the parent suggested a name of an s.4 candidate to the executive committee of the group as a rescuer and the committee has approached him/her for guidance.

As a chemistry learner,

TASK

Write a brief message that candidate will deliver to the group members.

Item 8 (soapless detergents)

People in Kisinza village only have access to borehole water which is not effective in cleaning clothes when soap is used. A local investor has been cleared by government to set up an industry that makes soapless detergents in the area however he is facing resistance from the community members about the issue of starting up the factory and he is equally lacking knowledge about the manufacturing process.

The head teacher has appointed you to go and represent the school in the meeting organized by the chairperson of the area to settle the wrangles between the investor and the citizens of the area.

TASK

Write a message you would deliver in this meeting.

ITEM 8 (ethanol)

Many people in villages make a living by manufacturing local waragi (ethanol). However, the government is against the business due to associated challenges. The area Member of Parliament wants to sensitize the community about the large-scale production process and its impact to enable them understand the government position.

The area Member of Parliament has contacted you as a student with the knowledge of chemistry

in your village to provide relevant information.

Task:

Make a write-up to use upon meeting the community.

PART II: EXISTENCE OF NATURAL RESOURCES IN THE ENVIRONMENT AND THEIR IMPORTANCE IN EVERY DAY LIFE

ITEM 1 (Oil)

Recently, oil deposits were discovered in Western Uganda. A Chinese investor has been contracted by the government to extract the oil but the people around are scared of the outcomes. You have been invited by the LC chairman of that area to attend one of their meetings, and you are the only person who has some knowledge about natural resources, so the chairman has requested you to give a talk about the issue.

As a chemistry learner,

Task

Make a write up of your speech

ITEM 2 (rocks and minerals)

In Uganda, there are many mineral reserves and rocks. Due to the rapid population growth, their exploitation is causing proportional environmental degradation. The government through media houses wants to make public awareness on the matter.

Your school has been chosen to lead the environmental conservation campaign in your district. You have been chosen to present on one of the radio talk shows trusting your chemistry knowledge on natural resources.

TASK

Write down the information that can be conveyed

ITEM 3: (water)

Urbanization and industrialization have caused freshwater bodies to suffer from severe pollution. The Ugandan government aims to create public awareness regarding the natural resource through various initiatives.

One of the initiatives is to involve students with good knowledge of chemistry in radio talk shows.
TASK: Write the presentation you can use.

ITEM 4(air)

"Residents of Kampala are facing severe health risks due to poor air quality," was a headline in one of the recent editions of the New Vision newspaper. With the city's reputation tarnished and residents' health hanging in the balance, urgent action to raise awareness and clean the natural resource is needed, the paper continued to state.
The Kampala Capital City Authority (KCCA) is getting ready to improve the situation following the alarming revelation.
As a student of Chemistry who has learned about air as a natural resources

TASK

Write an article KCCA would use in response to the paper to sensitize the community of Kampala.

ITEM 5 (trees)
Uganda's forests are under pressure from illegal logging, agricultural expansion, and urban growth. Despite government attempts to advocate for sustainable forest management, these efforts have failed due to citizens' lack of awareness regarding the benefits and consequences.

Use your chemistry knowledge to create awareness on the matter.

TASK.
Make a write-up you can use upon meeting the citizens.

Item 6 (carbon based fuels)
In Uganda, people are voicing concerns about prolonged drought and unpredictable rain seasons, leading to difficulties in farming planning. The officer in charge of agriculture attributes these issues to the overuse of charcoal and kerosene for cooking, citing their environmental implications. However, many natives seem to struggle to grasp the connection between their energy consumption habits and the broader environmental impact.



You are expected to close a gap in understanding between the officer's perspective and the community's perception of the situation

TASK

Help the natives understand this connection better.

PRACTICAL ITEMS

Sample Item 1

A company is investigating an appropriate chemical method to generate heat for portable stoves. The idea involves using iron scrap to displace copper (II) ions in a chemical reaction, offering an eco-friendly alternative to fossil fuel stoves. The company aims to determine how much heat is produced by the reaction for every 25cm^3 of copper II sulphate solution used, so that they make it a viable option for outdoor cooking.

$$Fe(s) + Cu^{2+}(aq) \longrightarrow Cu(s) + Fe^{2+}(aq) + \text{Heat}$$

You are provided with:

- Solid P which is sample of Iron fillings from scrap
- BA1 which is Copper (II) sulphate solution
- Some apparatus

TASKS

(a) Design an experiment that can be used to determine the amount of heat evolved
(b) Carry out the experiment and determine the amount of heat involved
(c) Analyze the results and draw the conclusion

Sample Item 2

When baking cookies the process involves mixing baking soda with vinegar to create a chemical reaction that generates carbon dioxide gas. The gas makes the cookies rise and become fluffy

$$NaHCO_3(s) + CH_3COOH(aq) \longrightarrow CH_3COONa(aq) + CO_2(g) + H_2O(l)$$

One of the workers asked the manager why they use the powdered form not the granular form of the baking soda. The manager tried to explain the effect of particle size on the reaction but it still remained unclear to the worker. He took the worker to a laboratory and demonstrated using the reaction of magnesium with hydrochloric acid whose reaction rate also depends on particle size.

$$Mg(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$$

You are provided with;

- Magnesium powder
- Magnesium granules
- Hydrochloric acid
- Some apparatus

TASK

(a) Design an experiment you would carry out to help the worker understand the manager's explanation
(b) Carry out the experiment and record you findings
(c) Analyze your results and draw a conclusion

Sample item 3

A chemical manufacturing company is testing a new lubricant for heavy machinery. It must have a freezing point above 60 to ensure it remains effective in extreme hot environments. The operations manager needs to verify whether the newly acquired lubricant meets this criteria to ensure its suitability for use.
You have been given a sample of solid **P** whose suitability as a raw material depends on its melting point.

TASK

(a) Design an experiment the factory can use.
(b) Carry out the experiment and record your findings
(c) Analyze the data and draw your conclusion

Sample item 4

A company is planning to use metal X and hydrochloric acid to produce hydrogen gas to be used in fuel cells for generating electricity. Heat generated or absorbed influences both the reaction speed and hydrogen quality. The company wants to determine the heat change for a reaction between the metal (X) and dilute hydrochloric acid to be able to make a decision on whether to use it or not.
Metal **X** reacts with hydrochloric acid according to the following equations;

$X(s) + 2HCl(aq) \longrightarrow XCl_2(aq) + H_2(g)$ + Heat

You are provided with:

- Solid P which is sample of metal X
- BA1 which is a dilute solution of hydrochloric acid
- Some apparatus

TASKS

(a) Design an experiment that can be used to determine the amount of heat involved during the reaction
(b) Carry out the experiment and obtain data to determine the amount of heat involved during the reaction.
(c) Analyze the data and draw your conclusion

Sample item 5

A healthcare company is developing a new chewable antacid tablet and is evaluating the potential use of a specific alkali, represented as $X(OH)_n$, as the active ingredient. The company wants to confirm if heat produced varies with the volume of acid added to the alkali and how much heat is produced by the reaction, so that they are able to work on dosage.

The alkali reacts with hydrochloric acid according to the following equation.

$$X(OH)_{n(aq)} + nHCl_{(aq)} \longrightarrow XCl_{n(aq)} + nH_2O_{(l)} + Heat$$

You are provided with:

- BA1 which is a sample solution of the alkali
- BA2 which is dilute hydrochloric acid

TASK:

(a) As a learner of chemistry;

(i) Design an experiment to determine the heat produced for every $20cm^3$ of BA1 used

(ii) Carry out the experiment and record your results appropriately

(b) (i) Obtain the maximum heat produced for the volume of BA1 used

(ii) What recommendation is useful to the company?

Sample item 6

A laundry service provider in one of the urban centers in Uganda has to choose the best water for effective washing with soap. He requested the men who supply to bring him samples from the two different water sources. He would want to discover which type of water minimizes soap wastage hence more effective in cleaning.

You are provided with:

BA1: which a soap solution
BA2: which is water sample from supplier A
BA3: which water sample from supplier B

Task:

(a)As a learner of chemistry;

(i) Design an experiment a laundry service provider can use

(ii) Carry out the experiment and record your findings.

(b) Show from your findings how the laundry service provider can make choice on the type of water to be used

INSTRUCTIONS TO THE TEACHER ON THE PRACTICAL ITEMS

Sample item 1

$50cm^3$ of BA1(1M copper (II) sulphate solution), 2g of iron powder, Plastic beakers, Thermometer, Measuring cylinder, Burette

Sample item 2

2M hydrochloric acid, Magnesium powder and magnesium granules, stop clock, thermometer

Sample item 3

P = Stearic acid or Naphthalene

Sample item 4

2 plastic beakers, 1 thermometer, 1 measuring cylinder of $50cm^3$ or 100 cm^3, 1 stop clock, weighing scale.
2M hydrochloric acid , solid P is Magnesium granules

Sample item 5

$50cm^3$ of BA1 (2M sodium hydroxide solution), $50cm^3$ of BA2, 1M hydrochloric acid), Plastic beakers, Thermometer, Measuring cylinder, Burette Pipette

Sample item 6

BA1 is a soap solution made by dissolving 6g of white star soap per litre of solution,
BA2 is water sample from supplier A made by dissolving 1.2 g of magnesium sulphate per litre of solution
BA3 is water sample from supplier B made by dissolving 0.5g of magnesium sulphate per litre of solution

SOLUTIONS

SECTION A

Food additives, Drugs and medicines, Nuclear processes, Soap

ITEM 1 (i)

(a) The ingredients used are **food additives** which are either: **Natural or Artificial/synthetic**,

(b) The food additives maintain or improve flavour, safety, freshness, texture and appearance of food.

(c)Excessive use of Artificial/synthetic food additives increases risk of high blood pressure and other communicable diseases, causing illness

Mitigation; Controlled amounts of artificial food additives should be used.

Both natural and artificial food additives have chemical compounds that are useful and some of which are harmful to the body but natural food additives have them in lower concentrations.
It is, therefore, advisable to use more of the natural ones than the synthetic additives.

ITEM 1 (ii)

(a) The product to use is **antibiotics,** which are **herbal**, or **modern**

(b) Inhibits growth of bacteria / kills bacteria

(c) Excessive use of the antibiotics causes **dizziness, headache, hearing loss, body organ damage hence health complications.**
Mitigated by: controlled use or following doctor's prescription

Evaluation: Both herbal and modern medicines are used to kill bacteria, but modern medicines are needed in smaller amounts and take a shorter time to cure the disease

ITEM 1 (iii)

(a) The product is **detergents**, which are either **soapy** or **soapless**

Mode of action: The detergents facilitate the emulsification and removal of grease /oil / dirt.

Alternatively

Detergents facilitate breakdown of fats into small parts.

A soap molecule contains two parts; namely; the water-soluble /polar carboxylate head / hydrophilic end and non-polar tail/fat soluble part / hydrophobic part.
-During washing, soap acts by lowering the surface tension between water and oil/grease/other water insoluble materials and also emulsifies them. The hydro-carbon tail becomes attached to dirt /oil /fat while the polar head dissolves in water. With constant agitation, the dirt is pulled off the cloth and gets dispersed in water as tiny droplets which are then poured away. The cloth is then rinsed several times and dried.

(b) Soapy detergents contain chemicals that can cause:

- Skin burns / blisters / skin irritation and hence pain or cancer mitigated by thoroughly washing the affected areas or by use of gloves during washing
- Eye redness and pain; hence loss of vision mitigated by thoroughly washing the affected areas
- Soapless detergents contain phosphates which cause algae bloom and hence polluting water that kills the aquatic organisms

Evaluation of the products

Similarities:

- Both soapy detergents and soapless detergents are salts of Organic acids of long carbon chain.
- Both soapy detergents and soapless detergents are effective cleansing agents in soft water / rain water.

Differences;

Soapy detergents	**Soapless detergents**
• Form scum with hard water	• Do not form scum with any form of water
• Gentle on skin during cleansing	• Not gentle on skin during washing
• Sodium salts of carboxylic acid of long chains and cannot be used in strongly acidic solutions	• Sodium salts of long chain benzene sulphonic acids and can be used in strongly acidic solutions
• Are biodegradable	• Are non-biodegradable

ITEM 1 (iv):

(a) The process is **nuclear reactions**, categorized into: **Nuclear fission** and **nuclear fusion**

(b) When uranium is bombarded with fast moving neutrons its atomic mass increases and the nucleus becomes unstable. Therefore it spontaneously splits into two lighter nuclei, three neutrons and energy. The three neutrons cause more successive disintegration, amplifying the energy given out. This can be used to boil water to steam which can eventually drive turbines and produce electricity.

Equation

$$^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \longrightarrow {}^{141}_{56}\text{Ba} + {}^{92}_{36}\text{Kr} + 3{}^{1}_{0}\text{n} + \text{energy}$$

However, the process has the following challenges

- The energy emitted can cause **mutations**, i.e. the emissions can cause sudden change in the arrangement of DNA/the genetic composition of the cells, hence **altering characteristics of organism.** This can be **mitigated** by wearing protective gears such as lead coats.
- The energy emitted can cause **cancer** resulting into **death, mitigated** by wearing protective gears such as lead coats or by posting warning information in the working area

(c) - **Both produce energy**, **but nuclear fission produces more energy than nuclear fusion**
- **Both are initiated by energy**, **but nuclear fusion requires a lot of energy to start** while nuclear fission requires little energy to start

TRENDS, POLYMERS, QUANTITY OF MATTER, PERIODIC TABLE, STRUCTURES AND BONDS

ITEM 2 (i):

a) He should realize that packaging materials may be;
Synthetic/artificial because they are man- made e.g. polyethene bags or **Natural** because they are God made e.g. cellulose in paper bags.

b) - Polyethene is tough

- It is insoluble in water
- Water proof
- Durable
  Suitable for making packing bags for wet products.

Alternatively,

- Paper can easily be decomposed by fungi and bacteria (biodegradable),
- it is foldable
- absorbs moisture
- it is stiff
- strong
  Suitable for making packing boxes for dry products.

Impact to the environment

- Polyethene is non- biodegradable, hence pollutes the soil environment, limiting free circulation of water and air in the soil

Mitigation; Reduce on its use, dispose it off properly, reuse or recycle.

- Paper easily catches fires, so can lead to fire outbreaks and damage

Mitigation; not using it near fire

ITEM 2 (ii):

(a) X is a **metal**, since it forms ions by loss of electrons, for example Calcium.

(b) Mass of oxygen in the oxide = 0.5 – 0.3 = 0.2g

Symbols of elements in the oxide	X	O
Composition by mass	0.3	0.2
Number of moles	$\frac{0.3}{24} = 0.0125$	$\frac{0.2}{16} = 0.0125$
Simplest ratio (mole ratio)	$\frac{0.0125}{0.0125}$	$\frac{0.0125}{0.0125}$
	1	1

Hence the formula of the oxide is **XO**

(c) - When in contact with drinking water, especially in large amounts can cause **cancer** leading to death,**mitigated** by purifying the water
- Their accumulation in soil can be absorbed by plants which are consumed by humans causing **cancer** and then**death**, **mitigated** by consuming plant materials with the right amount of mineral content
- When contaminated in air can be **inhaled**, hence **causing respiratory diseases**
  Mitigated by purifying the air

ITEM 2 (iii)

(a) Salt is **an ionic compound** because it is formed by complete transfer of electrons from a metal to a non-metal atom, e.g. sodium chloride
It has the following characteristics

- dissolves readily in water
- it is a crystalline solid at room temperature
- conduct electricity in molten and aqueous state
- has a high melting and boiling point
- its composed of particles called ions

Alternatively

Sand is a covalent compound because it is formed as a result of sharing electrons between non-metal atoms
It has the following characteristics

- does not dissolves in water
- does not conduct electricity
- has a giant covalent structure
- exists as a molecule
- is not made up of ions

Uses

Salt is used as a flavour enhancer, used as a preservative.

Sand is used during construction, used as an electrical insulator

(b) - Over use of the salt can lead to **high blood pressure** that may result into **death**, **mitigated** by using it in regulated amounts
- lead to **kidney disorders** causing **illness**, **mitigated** by using it in regulated amounts

ITEM 2 (iv):

(a) (i) X, Y and Z are metals, since they form ions by loss of electrons, for example calcium and potassium
A, Q and M are nonmetals, since they forms ions by gain of electrons, for example oxygen, sulphur
W is a metalloid because it has both metallic and non-metallic properties, for example silicon
(ii) There is a sharp increase in melting points from X to Y because of the decrease in atomic radius and increase in the number of electrons each metal atom contributes towards metallic bond formation resulting into stronger metallic bonds
Melting point increases slightly from Y to Z because of the slight increase in the strength of the metallic bond due to the decrease in the atomic radius
W has the highest melting point because it adopts a giant atomic structure with many strong covalent bonds that require a lot of heat energy to break.
A, Q and M are non-metals which exist as molecules with simple molecular structures and the melting point decreases with decrease in the strength of the Van derWaals forces due to decreasing molecular mass.

(b) **Uses**

Metals are used in electronic devices, in construction, manufacture of aeroplanes
Non-metals are used as electrical insulators, manufacture of drugs,fertilizers
Metalloids, used in production of alloys, as flame retardants, as semiconductors in the manufacture of dry cells and batteries

Environmental impacts
Metals

- when in contact with drinking water, especially in large amounts can cause cancer leading to death **mitigated** by purifying the water
- their accumulation in soil can be absorbed by plants which are consumed by humans causing cancer leading to death, **mitigated** by consuming plants with the right amount of mineral content
- when contaminated in air can be inhaled, hence causing respiratory diseases, **mitigated** by purifying the air

Nonmetals

When burnt in air produce acidic gases which pollute the atmosphere causing respiratory diseases, **mitigated** by burning them cautiously

Metalloids

During mining, smelting and industrial processes, they can **get in contact with water and soil**, polluting them and **causing harm to organisms**, **mitigated** by handling them carefully during the above named processes

SECTION B

PART I:

Contribution of chemistry to our economy

Copper, iron, aluminium, nitric acid, sulphuric acid, fertilizers, ethanol, detergents, sodium hydroxide, chlorine gas, bio gas, oxygen gas, cement

Item 1 (cement)

Raw materials; lime stone, sand and clay

Process of production;
The lime stone obtained from the quarry is mixed with sand and clay in the correct proportions and crushed into a fine powder.
The powder is then mixed with water and allowed to flow down a **rotating tank** (**or cylinder or cement kiln**) where it is strongly heated at about 1500^{o}C
Limestone decomposes into calcium oxide and carbon dioxide
$CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$
Calcium oxide reacts with sand forming calcium silicate and also reacts with aluminium oxide forming calcium aluminate.
$2CaO(s) + SiO_2 \longrightarrow Ca_2SiO_3$
$3CaO(s) + Al_2O_3 \longrightarrow Ca_3Al_2O_6$
Calcium silicate and calcium aluminate form a mixture called clinker
Gypsum is added to clinker to moderate the setting of the cement and the lumps are then crushed by machine to obtain the fine cement powder
$Clinker + CaSO_4.2H_2O \longrightarrow Cement$

Side effects of the process of production

- **Effluent discharge** from the cement plant can **contaminate water bodies**, affecting aquatic life and quality of water, **mitigated** by treatment of waste water through sedimentation and filtration before discharge / recycling the water with in the plant.
- **Carbon dioxide emissions** to the atmosphere can **cause global warming**, this is **mitigated** by recycling of carbon dioxide
- **Inhalation of air contaminated** with cement dust **causes respiratory diseases**, **mitigated** by wearing personal protective equipments

Social benefits

- **Source of employment opportunities**, hence **improved income** and therefore **better standards of living**
- **Increased government revenue** through taxes hence **improvement of infrastructure** such as roads, schools, health facilities leading **development of the society**.
- **Provision of market** for goods of the community members, hence **generating income**, leading to **better lives**

- **Production of cement for use** during **construction** by the community members, **hence acquiring better houses**

ITEM 2 (copper)
Raw materials used; Copper pyrites ($CuFeS_2$)

Process of production;

The ore (copper pyrites) is crushed into powder and mixed with water containing special oils called frothing agents.

Air is brown into the mixture and a froth forms. Earthly impurities in the ore are wetted with water and sink to the bottom of the **flotation tank** while the copper pyrites floats on the surface in the froth.

The froth is skimmed off, and an acid added to it to break it.
The ore is filtered off, dried and roasted to convert it to copper(I) sulphide, sulphur dioxide and iron (II) oxide

$$2CuFeS_2(s) + 4O_2(g) \longrightarrow Cu_2S(s) + 2FeO(s) + 3SO_2(g)$$

Sand is then added and the mixture heated in absence of air to convert iron(II) oxide to iron (II) silicate liquid.

$$FeO(s) + SiO_2 \longrightarrow FeSiO_3(l)$$

The ore is then heated in a controlled amount of air to produce impure copper and sulphur dioxide;

$$Cu_2S(s) + O_2(g) \longrightarrow 2Cu(s) + SO_2(g)$$

Or, $2Cu_2S(s) + 3O_2(g) \longrightarrow 2Cu_2O(s) + 2SO_2(g)$
Then; $Cu_2S(s) + 2Cu_2O(s) \longrightarrow 6Cu(s) + SO_2(g)$
The copper produced is then **purified by electrolysis of copper (II) sulphate** using this produced impure copper as the anode and a pure copper as the cathode
The impure copper anode dissolves in the electrolyte producing copper (II) ions which move to the cathode where they are discharged to form pure copper.
Anode: $Cu(s) \longrightarrow Cu^{2+}(aq) + 2e$
Cathode: $Cu^{2+}(aq) + 2e \longrightarrow Cu(s)$
Side effects of the process of extraction of copper

- **Release of sulphur dioxide** causes **air pollution resulting into acid rains that affect plant growth** and also causes **global warming**, **mitigated** by treatment of the gas or installing catalytic converters in the exhaust pipes
- **Exposure to copper fumes** or **dust** can cause **poisoning leading to cancer and even death**, **mitigated** by personal protective equipments

Social benefits
- **Source of employment opportunities**, hence **improved income** and therefore **better standards of living**
- **Increased government revenue** through taxes hence **improvement of infrastructure** such as roads, schools, health facilities leading **development of the society** improving standards of living
- **Provision of market** for goods of the community members, hence **generating income**, leading to **better lives**

ITEM 3 (iron)

Raw materials: Iron ore e.g. Haematite, Coke, Lime stone and air
Process of production;
Iron is extracted from its ores using a **blast furnace**

Haematite, coke and limestone are mixed together and introduced into the **blastfurnace** from the top up where hot air is forced

As the hot air rises up the furnace it reacts with the coke to form carbon dioxide.

i.e. $C(s) + O_2(g) \longrightarrow CO_2(g)$

As the carbon dioxide formed rises up the furnace it is reduced by the unburnt coke to carbon monoxide

i.e. $C\ O_2(g) + C(s) \longrightarrow 2CO(g)$

The carbon monoxide then reduces the haematite to molten iron;

$2Fe_2O_3(s) + 3CO(g) \longrightarrow 4Fe(s) + 3CO_2(g)$

The molten iron then sinks to the bottom of the furnace where it is topped off

The lime stone decomposes into calcium oxide which reacts with the sand, a major impurity in haematite to form slag which drops to the bottom of the furnace and floats on top of the molten iron.

$CaCO_3(s) \longrightarrow CaO(s) + CO(g)$

$CaO(s) + SiO_2(g) \longrightarrow CaSiO_3(l)$

The iron obtained is impure and can be **purified by converting it onto wrought iron, by oxidizing the impurities**

Side effects of the process of extraction

- **Emission of poisonous gases** leading to **air pollution that may cause suffocation** hence illness or death, **mitigated** by treatment of these gases before emission to the atmosphere
- The **un reacted carbon dioxide can escape** into the atmosphere causing **global warming**, **mitigated** by recycling the carbon dioxide
- **Emission of heat** from the furnace causing **rise of temperature of the surrounding environment, which affects the people**, **mitigated** by installing heat absorbers around the furnace

Social benefits of process of extraction of iron

- Source of employment opportunities in the factory, hence improved income and therefore better standards of living
- Increased government revenue through taxes hence improvement of infrastructure such as roads, schools, health facilities leading development of the society and better lives
- **Provision of market** for local goods of the community members, hence **generating income**, leading to **better lives**

ITEM 4 (fertilizers)

The local investor will produce ammonium sulphate or ammonium nitrate fertilizer and the production will be as follows

For ammonium sulphate,

Raw materials; Nitrogen from the air, Hydrogen from water gas, sulphur and air

Process of production;

First is the production of ammonia

Nitrogen and hydrogen gases are purified, dried and mixed in a volume ratio of 1:3 respectively in a **reactor vessel**.

The mixture is passed over finely divided iron catalyst, at a low temperature of 400 -500^oC under high pressure of 200 atm, hence forming ammonia, through the Haber process.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

Then, sulphuric acid is manufactured by the contact process

Sulphur is burnt in air to produce sulphur dioxide

$S(s) + O_2(g) \longrightarrow SO_2(g)$

Sulphur dioxide, is purified and dried to prevent poisoning of the catalyst. It is then heated with dry pure oxygen gas at a low temperature of 400 – 500^oC under high pressure of about 1 – 3 atm in the presence of vanadium (v) oxide forming sulphur tri oxide.

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

Sulphur trioxide is then dissolved in a little concentrated sulphuric acid to produce a fuming liquid called oleum.

$SO_3(g) + H_2SO_4(l) \longrightarrow H_2S_2O_7(l)$

The oleum is diluted with a known amount of water to give 98% concentrated sulphuric acid.

$H_2S_2O_7(l) + H_2O(l) \longrightarrow 2H_2SO_4(aq)$

Ammonium sulphate is then formed by reacting ammonia gas with concentrated sulphuric acid

$2NH_3(g) + H_2SO_4(l) \longrightarrow (NH_4)_2SO_4(s)$

The fertilizer is then **concentrated by crystallization**

For ammonium nitrate fertilizer nitric acid will be manufactured as follows

Ammonia gas from the Haber process is burnt in dry pure oxygen of the air, in the presence of platinum catalyst, to form nitrogen monoxide gas with in a **reaction vessel**

$4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(l)$

Nitrogen monoxide formed is then reacted with oxygen to form nitrogen dioxide gas;

$2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$

Nitrogen dioxide gas is then mixed with oxygen and the mixture absorbed in water to form nitric acid

$4NO_2(g) + O_2(g) + 2H_2O(l) \longrightarrow 4HNO_3(aq)$

The nitric acid formed is then reacted with ammonia to form ammonium nitrate fertilizer which is concentrated by crystallization

$NH_3(g) + HNO_3(aq) \longrightarrow NH_4NO_3(s)$

Side effects of the process of production of fertilizers

Emission of ammonia, nitrogen oxides and sulphur oxides **can pollute the air, causing respiratory problems** and **environmental issues**, **mitigated** by installing catalytic converters to convert them to less toxic substances.

Social benefits

- **Source of employment opportunities**, hence **improved income** and therefore **better standards of living**
- **Increased government revenue** through taxes hence **improvement of infrastructure** such as roads, schools, health facilities leading **development of the society**.
- **Development of small scale businesses**, hence generating income, leading to **better lives**
- **Availability of fertilizers**, hence **better plant growth** in the community **leading increased crop yields**.

ITEM 5 (chlorine and sodium hydroxide)

NOTE: This item requires manufacture of chlorine, but the solution also gives room for manufacture of sodium hydroxide

Raw materials used; Brine (concentrated sodium chloride solution)

Process of production;

Sodium hydroxide and chlorine are manufactured by <u>electrolysis</u> of brine

Brine which mainly contains sodium ions, chloride ions, is placed in a **diaphragm cell** that consists of a graphite anode and a steel cathode.

Brine ionizes according to the equation;

$NaCl(aq) \longrightarrow Na^{+}(aq) + Cl^{-}(aq)$

The sodium ions migrate to the cathode where they are preferentially discharged to form sodium which reacts with water to form **sodium hydroxide** solution that can be **purified by evaporation to dryness** to form solid sodium hydroxide,

$Na^{+}(aq) + e \longrightarrow Na(s)$
$2Na(s) + 2H_2O(l) \longrightarrow 2NaOH(aq) + H_2(g)$

Chloride ions migrate to the anode where they are preferentially discharged to form chlorine gas which is then packed in strong cylinders.

i.e. $2Cl^{-}(aq) \longrightarrow Cl_2(g) + 2e$

Side effects of the process of production;

- **Contact with sodium hydroxide** causes **severe burns to the eyes, skin, digestive system resulting into permanent damage of the body organs and even death**, **mitigated** by wearing personal protective gears
- **Repeated inhalation of sodium hydroxide vapor** causes **lung damage**, **mitigated** by wearing protective gears
- **Inhalation of chlorine** can **cause death** as it is a poisonous gas, **mitigated** by wearing protective gears
- **Escape of chlorine into the surrounding atmosphere** can **pollute the resulting into acid rain which leads to crumbling of buildings**, **lowering soil pH** and **corrosion of roofs made of iron**, **mitigated** by regular maintenance of the plant.

Social benefits

- **Source of employment opportunities**, hence **improved income** and therefore **better standards of living**
- **Increased government revenue** from taxes hence **improvement of infrastructure** such as roads, schools, health facilities leading **development of the society**.
- **Provision of market** for goods of the community members, hence **generating income**, leading to **better lives**
- **Provision of sodium hydroxide** which is **used as a raw material in the manufacture of soap**, hence the **community members can easily wash their clothes and be clean**
- **Provision of chlorine** which is used **to treat water**, hence **killing germs and minimizing infections among the community members**

ITEM 6 (oxygen)

Raw material; liquid air / air.

Process of production;

Air is passed through **air filters** to remove dust and smoke particles. It is then passed through concentrated sodium hydroxide solution to remove carbon dioxide,

$2NaOH(aq) + CO_2(g) \longrightarrow Na_2CO_3(aq) + H_2O(l)$.

Air free from carbon dioxide is now passed through Silicon(IV) oxide to absorb water vapour. Carbon dioxide and water vapour are removed from air before it is liquefied because they would solidify and block the apparatus.
The air is then compressed at 200 atmospheres and allowed to cool by making it escape into a large space through a jet.
The process of cooling is repeated several times to obtain liquid air at about –200^{o}C. The liquid air is **fractionally distilled** using a **fractionating column / tower**.
Nitrogen boils off first because it has a lower boiling point (–196^{o}C) leaving behind oxygen with a higher boiling point (-183^{o}C). . Pure oxygen is then stored under pressure in steel cylinders.

Side effects of the process of production
- Explosion of oxygen cylinders due to high pressure **causing injuries and fire outbreaks** also **resulting into damage to equipment**, **mitigated** by;
* regular maintenance and monitoring of cylinders.
* keeping cylinders in cool areas to avoid exposure to heat.

- Exposure to liquid oxygen can **cause severe skin and eye irritations and burns, loss of vision and cancer**, m**itigated by**:
* Posting hazard and warning information in the working area.
* Communicating all information on the health and safety hazards of oxygen to potentially exposed workers; for example; submerging the affected body parts in warm water.

Social benefits
- **Source of employment opportunities**, hence **improved income** and therefore **better standards of living**
- **Increased government revenue** from taxes hence **improvement of infrastructure** such as roads, schools, health facilities leading **development of the society**.
- **Development of small scale businesses**, hence **generating income**, leading to **better life**
- **Availability of oxygen for patients**, hence **saving lives of the people in the area** and living a **better health**

Item 7 (soapy detergents)
Raw materials; vegetable oil, concentrated sodium hydroxide, concentrated sodium chloride

Process of production;

Vegetable is mixed with concentrated sodium hydroxide solution (or potassium hydroxide solution) in a **non aluminium tank** and the mixture boiled while stirring until no further change occurs, and allowed to cool.

Concentrated sodium chloride solution is added into the mixture to precipitate (salt out) soap from the solution. Solid soap is skimmed off, washed and dried.

Side effects of the process of production
- **Discharge of wastewater containing surfactants solvents, phosphates and other chemicals into water bodies** can cause **contamination** or **pollution**, **harming aquatic life and affecting water quality**, **mitigated** by treatment of the wastes
- **Accidental spills or leaks of raw materials and finished products** can lead to **contamination** or **pollution**, affecting soil fertility and hence plant growth, **mitigated** by use of proper storage and handling procedures for raw materials and chemicals.

Social benefits

- Source of revenue to the government through taxes, hence, improved infrastructures for example; health facilities, roads etc hence improvement in the other sectors such as health and transport resulting into living a better life.
- Source of **employment** resulting into **improved income** hence, **better standards of living**.
- **Provision of market** for goods of the community members, hence **generating income**, leading to **better lives**
- **Provision of soap for use by the community members** to be used for **washing and bathing hence maintaining maintain cleanliness**

Item 8 (soapless detergents)
Raw materials: concentrated sulphuric acid, long chain of alkyl benzene, sodium hydroxide
Process of production
A long chain of alkyl benzene is heated with concentrated sulphuric acid in a **reactor vessel** to form alkyl benzene sulphonate, which is then cooled and then reacted with sodium hydroxide solution to form alkyl benzene sodium sulphonate which is then **purified by evaporation**, **evaporated** and cooled to obtain the soapless detergent.

Side effects
When the non-biodegradable soapless detergents **leak to water, they pollute it causing death of aquatic organisms, mitigated by**, not pouring water containing soapless detergents near water bodies.

Social benefits, same as above

ITEM 9 (ethanol)
Raw material: bananas, sorghum, water

Process of production
The bananas are covered after harvesting for about a week to ripen. The carbohydrates are converted into maltose by means of enzymes diastase
The ripe bananas are put in a **wooden trough** and then squeezed between spear grass to extract the juice from them while adding water.
The mixture is filtered to obtain juice
Sorghum which has been roasted is added to the filtered juice and the mixture is stored.
The mixture is then covered in a warm place to cut off oxygen supply to allow fermentation to occur.
Yeast from sorghum provides maltase enzyme which catalyses hydrolysis of maltose to glucose
Zymase enzyme from yeast catalyses the decomposition of glucose to ethanol which is crude
The crude ethanol is **purified by fractional distillation** to obtain pure ethanol.
Side effects
Bursting of distilling tanks, causing **wounds and even death to the workers**, **mitigated** by regular inspection and maintenance of the distilling tank

Social benefits
- Source of **employment** resulting into **improved income** hence, **better standards of living**.
- **Provision of market** for goods of the community members, hence **generating income**, leading to **better lives**
- **Provision of ethanol to the community members** or **use as a sanitizer and disinfector** hence **living a better health**

PART II
Natural resources

ITEM 1 (Oil)

Category of the natural resource: Oil is a **non renewable natural resource** because it cannot be replenished / replaced by natural processes in man's life time or it gets used up.

Composition: alkanes, alkynes, paraffin, petrol and diesel.

Impact of the human activities on the natural resource

- **combustion of oil, releases** carbon dioxide **which can results into acid rain that interferes with the soil pH**, hence affecting plant growth, also leads to **global warming**
  Mitigated by increased afforestation such that the trees absorb carbon dioxide
- **Oil spills by humans** can **reach water bodies cutting off oxygen supply causing suffocation of aquatic animals**.
  Mitigated by proper waste management routines

Importance of the natural resource

When purified it produces various chemicals like motor fuels, lubricants, paints, detergents, drugs, etc.

ITEM 2 (rocks and minerals)

Category of the natural resource

Rocks and minerals are **non-renewable natural resources** because they cannot be replenished / replaced by natural processes in man's life time. **Or** they get used up.

They are categorized as: **Igneous rocks, Sedimentary rocks** and **Metamorphic rocks**

- **Igneous rocks** , comprising of minerals like **Quartz**, **Feldspar**, and **Olivine**
- **Sedimentary rocks**, composed of minerals like **Calcite**, **Quartz**, **Clay materials**, **Gypsum**
- **Metamorphic rocks**, composed of minerals like **Garnet**, **Mica(biotite** and **muscovite)**,**Quartz** and **Feldspar** (**Marble** or **Gneiss**)

Impact of the human activities on the natural resource

- **Stone quarrying produces dust particles** which **erode into water bodies, hence reducing on its quality**
  Mitigation extracting carefully and use of personal protective equipments
- **Stone quarrying and mineral extraction removes top soil and ditches** which **degrades the soil environment**, **hence affecting growth of plants, hence destruction of vegetation cover**
- **Mineral extraction** results into **breaking of rocks into smaller stones and gravels** which **depreciates the rocks**
  Mitigation, careful extraction

Importance of the natural resource

- Rocks are broken into hard core, gravel or panels used as materials for construction of roads, bridges, houses
- They are usefully in formation of soil by a process of weathering

ITEM 3: (water)

Category: Water is a renewable natural resource because it can be replaced/replenished by natural processes in man's life time.

Composition: Dissolved oxygen, mineral salts, aquatic plants and big animals as well as microorganisms and pollutants from man's activities.

Impact

Release of hot water as an effluent from industries into the water bodies, **increase the temperature of the water** bodies killing aquatic organisms. **Mitigated by** cooling the water before discharge and use of hot water reservoirs

Excessive use of fertilizers during crop farming, which infiltrate into water bodies, hence **polluting water**, **resulting into eutrophication** of nearby water bodies

Mitigated by use of organic fertilizers e.g. manure from both animal and plant waste which are biodegradable and reduce on use of synthetic fertilizers

Importance
Water bodies are very useful in rain formation which is useful for proper plant growth

ITEM 4 (air)
Category: Air is a renewable natural resource because it can be replaced/replenished in man's life time.

Composition: Nitrogen gas, oxygen gas, carbon dioxide gas, rare gases, water vapour and dust.

Impact
Burning of fossil fuels, increases amount of carbon dioxide gas thus **trapping a lot of heat in the atmosphere thereby causing global warming** and **consequently desertification**.
Mitigated by increased afforestation to absorb carbon dioxide from the atmosphere as quickly as it is formed

Importance
Air contains oxygen which is used for respiration and carbon dioxide which is used for photosynthesis

ITEM 5 (trees)
Category: Trees and natural vegetation are renewable natural resources because they can be replaced/replenished by natural processes in man's life time.

Composition Trees and natural vegetation are made up of cellulose which is a carbohydrate (made up of important elements like carbon, hydrogen and oxygen), and other minerals such as magnesium, nitrogen, etc.

Impacts
Charcoal burning involves **cutting down of trees which leads to deforestation** and **loss of habitat for wild animals**. **Mitigation:** use of charcoal briquettes made from waste organic materials, afforestation

Massive cutting down of tress leads to **increased amount of carbon dioxide** in the atmosphere resulting into **increasing temperatures of the earth**
Mitigation: Planting more trees

Importance
Trees provide herbal medicine, provide food, and purify air by adding oxygen and removing carbondioxide

END