CHAPTER 13 CARBON IN THE ENVIRONMENT

Fire wood	Wood charcoal	Briquette charcoal
		
		
Petroleum fuels	**Natural gas**	**Kerosene**

Key words	Learning Outcomes (LOs)
▪ Carbon ▪ Allotropes ▪ Carbon dioxide ▪ Fuels ▪ Renewable energy ▪ Non - renewable energy ▪ Greenhouse ▪ Global warming ▪ Pollution ▪ Hardness of water	**a)** Understand how and why carbon compounds are used as fuels. **b)** Know and appreciate the difference between renewable and non – renewable fuels and understand that non – renewable fuels are not sustainable. **c)** Know and appreciate the impact of burning carbon – based fuels on the environment. **d)** Understand the processes of making charcoal, but recognize that the use of charcoals as fuel is cheap, efficient, and sustainable only if it is made from wood that can be regrown easily. **e)** Know and appreciate the physical properties and uses of carbon dioxide. **f)** Understand how the increase in carbon dioxide level in the air can cause the atmospheres and the oceans to get warmer.

▪ Carbon cycle	**g)** Understand what greenhouse gases are, where they come from, and how they are affecting climate. **h)** Understand the origin of hard water in limestone areas and investigate how it can be softened. **i)** Understand how the properties and uses of the allotropes of carbon relate to their structures.

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

13.1. INTRODUCTION

In this chapter, you will explore the relevancy of the element carbon in supporting life. You will also understand that carbon is one of the most successful elements on Earth, for instance considering all household materials, shop items, food, glass, oils, polymers, plants and animals are all made up of carbon element except some metals which are not alloys. In general, all living and non-living things and their products contain carbon atoms

13.2. CARBON – BASED FUELS AS NATURAL RESOURCES

These are carbon containing compounds that burn in air to produce heat and light energy. It is classified into: **renewable** and non – **renewable** energy fuels.

13.2.1. RENEWABLE ENERGYFUELS AS NATURAL RESOURCES.

These are energy fuels derived from natural resources which can be replenished (regenerated) over short periods of time. **Examples of Renewable energy fuels**

a) Solar energy: a form of energy fuel derived from the sun's radiation using solar panels (photovoltaic cells) to generate electricity.

b) Wind energy: a form of energy generated through the kinetic movement of air molecules harnessed by wind turbines to produce electricity.

c) Hydropower: a form of energy fuel derived from the gravitational force of the falling (flowing) water, harnessed by water turbines or dam to produce hydro – electric power.

d) Biofuels: a form of energy fuel derived from plant waste materials and converted by anaerobic decomposers to generate electricity and methane gas.

e) Geothermal energy: a form of energy fuel derived from the molten magma produced and stored within the core of the Earth's crust to generate heat and electricity.

f) Nuclear energy: a form of energy fuel derived from nuclear reactions (Nuclear fission and nuclear fusion) to generate electricity.

g) Wood: a form of carbon – based fuel used to generate heat and light energies.

f) Charcoal: a form of carbon – based fuel used to generate heat and light energies.

13.2.1.1Renewable fuels as "sustainable fuels"

All forms of renewable fuels are considered to be **sustainable fuels**, this is because: -

(i) Prolong use of the fuels as energy source, does not deplete the natural resources,
(ii) They can be replenished within a very short period of time.
(iii) Their use as fuels, does not emit greenhouse gases such as carbon dioxide, Sulphur dioxide, methane, nitrogen oxides and water vapour that causes global warming.
(iv) Their continuous use for a long – time, does not produce pollutants such as carbon monoxide, Sulphur dioxide, nitrogen oxides, hence it exhibits environmental friendliness.

13.2.2. NON – RENEWABLE FUELS AS NATURAL RESOUCES

These are energy fuels obtained from natural resources that cannot be replenished (regenerated) over short periods of time. **Examples of Non – renewable energy fuels**

a) Coal: a form of carbon – based fuel obtained from fossil fuels used to generate heat and electricity in most industrial processes.

b) Crude oil: a form of carbon – based fuel derived from fossil fuels used to generate heat, electric and light energy. It includes kerosene, diesel, and petrol.

c) Natural gas: a form of gaseous fossil fuel that contains mainly of methane used for heating, cooking and electricity generation.

13.2.2.1. Non - renewable fuels is "unsustainable fuels"

All forms of non – renewable fuels are considered to be **unsustainable fuels**, because

(i) Prolong use of the fuels as energy source, deplete the natural resources,
(ii) They cannot be replenished/regenerated within a very short period of time since their formation occur over millions of years.
(iii) Their use as fuels, emit greenhouse gases such as carbon dioxide, Sulphur dioxide, methane, nitrogen oxides and water vapour thence causing global warming.

(iv) Their continuous use for a long – time, produce pollutants such as carbon monoxide, Sulphur dioxide, nitrogen oxides, hence causing air, soil and water pollutions.

13.2.2.2.Ways of making non – renewable energy fuels "sustainable fuels"

i) Encouraging capturing carbon dioxide emissions from combustion of carbon – based fuels and storing or converting them into harmless gas, to prevent them from entering into the atmosphere.

ii) Encouraging fuel efficiency in transportation, industry and power plants by use of catalytic engine converters to control the amounts of carbon dioxide gas in the atmosphere.

iii) Encouraging the use of renewable energy fuels such as solar, wind, hydroelectric power, and biofuels to reduce the total dependence on non – renewable fuels.

iv) Encouraging sustainable fuel practices through government policies, and regulations of non – renewable fuels by use of public means.

v) Encouraging fuel blending by mixing non – renewable fuels with renewable fuels or biofuels to reduce carbon dioxide levels in the atmosphere.

13.3 COMPOSITION OF (NON) – RENEWABLE FUELS

Fossil fuels (Carbon, hydrogen, nitrogen, Sulphur)

13.3.1. BURNING NON – RENEWABLE FUELS

(i) Carbon burns in air to form carbon monoxide and carbon dioxide gas.

Carbon + Oxygen ⟶ Carbon dioxide

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

Carbon + Oxygen ⟶ Carbon monoxide

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

(ii) Nitrogen burns in air to form nitrogen monoxide and nitrogen dioxide gas.

Nitrogen + Oxygen ⟶ Nitrogen monoxide

$N_2(g) + O_2(g) \longrightarrow 2NO(g)$

Nitrogen + Oxygen ⟶ Nitrogen dioxide.

$2N_2(g) + 4O_2(g) \longrightarrow 4NO_2(g)$

(iii) Sulphur burns in air forming Sulphur dioxide gas.

Sulphur + Oxygen ⟶ Sulphur dioxide

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

13.3.2.Side effects of burning non – renewable fuels

-Burning non – renewable fuels, emit greenhouse gases such as carbon dioxide gas, Sulphur dioxide gas, nitrogen oxides, which cause global warming.

-Burning of non – renewable fuels such as coal, crude oils, emit pollutants such as carbon monoxide, nitrogen oxides and Sulphur dioxide gas, which pollute air, reducing its air quality and formation of acid rain that corrode buildings and vegetation.

13.4. HOW TO MAKE CHARCOAL FROM WOOD

Wood charcoal is a form of renewable energy fuel used to provide heat and light energies in most homesteads, and other organizations such as schools, among others.

Step1: Wood selection

Tree species with hard woods, like mango, oak, hickory tree species are selected for making wood charcoal.

Step2: Wood preparation

The hard woods identified are felt down by cutting them into small pieces of woods. This increases the surface area to volume ratio aiding quicker conversion into charcoal.

Step3: Wood assembling

The small pieces of woods are assembled in bunches and covered fully with soil or placed in a traditional kiln or modern retort system, ready for burning into charcoal.

Step4: Wood carbonization

This is a process of burning wood into wood charcoal in the absence of oxygen. It can be processed in two ways:

i) Use of traditional kiln, where woods are covered by a kiln, or by covering the piled pieces of woods with heap of soil to cut off oxygen supply that would cause complete combustion of wood. It also allows the woods to be carbonized gradually over several days without burning out.

ii) Use of modern retort system, where woods are efficiently converted into wood charcoal by capturing and recycling the gases released during the burning process.

Step5: Collection of wood charcoal

This is done after carbonization process, to allow the charcoal cool down in the kiln or retort or heaps.

Step6: Wood charcoal sizing and packing

The large piece of charcoal is crushed into small sized pieces depending on the desired end products and packed in sacks.

13.4.1.Importance of using wood charcoal as renewable energy fuels

i) Wood charcoal has a high energy density, making it an efficient fuel source.

ii) Wood charcoal is carbon neutral since the amount of carbon dioxide released when charcoal burn is equal to the amount absorbed by green plants during photosynthesis.

iii) Wood charcoal is obtained from wood, a renewable energy resource, making it replenish able and sustainable through replanting trees.

iv) Wood charcoal is a Sulphur free fuel, reducing air pollution and acid rain.

v) Wood charcoal can be a cost – effective fuel option, especially in regions with abundant wood resources.

vi) Wood charcoal produces less particulate matter and volatile organic compounds, unlike other forms of fuel energies.

13.4.2.Ways of making the use of wood charcoal as renewable energy fuels "sustainable"

i) Encouraging reforestation and afforestation to replace those harvested, allowing forest replenishing. This reduces total depletion of natural resources.

ii) Encouraging the use of charcoal briquettes as an alternative form of fuels, since making them does not require cutting down trees.

iii) Encouraging the use of other forms of renewable fuels such as hydroelectric power, natural gas, and biofuels as other means of fuel energy.

iv) Encouraging and promoting the use of efficient energy saving stoves and cooking practices to reduce fuel consumption and pollutants emission.

v) Creating public awareness and education by promoting sustainable charcoal production and use by promoting responsible practices among charcoal producers and consumers.

vi) Establishing use of certification schemes and regulation policies to all charcoal makers, to ensure sustainable charcoal production and trade.

13.5. CARBON DIOXIDE GAS

Carbon dioxide gas has 0.03% by percentage volume it occupies in the atmosphere. Its concentration in the atmosphere can be decreased by photosynthesis and increased by respiration.

Laboratory preparation of Carbon dioxide gas:

What you need

Dilute hydrochloric acid, marble chips (calcium carbonate), gas jar, flat bottomed flask, delivery tubes, dropping funnel, wash bottles of concentrated Sulphuric acid and distilled water.

What to do

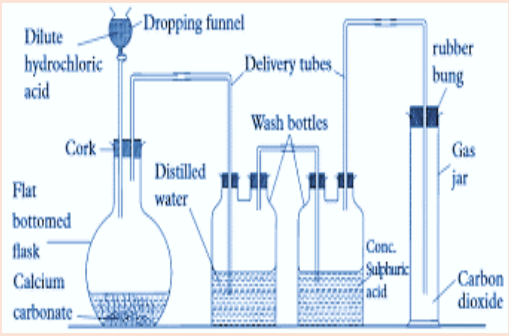
1.Fill the flat bottom flask with some marble chips, and connect the se up of the apparatus as shown in the fig 4.7.1

2. Run dilute hydrochloric acid by opening the tap of the dropping funnel. Note what happens in the flask.

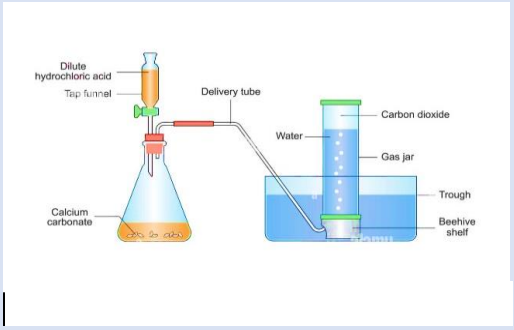
3. The colourless gas evolved is then passed into wash bottle of water to remove any acid fumes and concentrated Sulphuric acid to dry the gas.

4.The dry gas is then collected into the gas jar, by downward delivery method since the gas is dense than air

Preparation of dry carbon dioxide gas (figure 4.7.1)



Preparation of moist carbon dioxide gas



Discussion Questions: 13.7(a)

a) State what was your observation in the flat-bottomed flask

b) Red and blue litmus papers are indicators. If both blue and red litmus paper were dipped into wash bottle or tough of distilled water after the experiment.

(i) State would be observed to the litmus papers.

(ii) Suggest the name of the acid formed when carbon dioxide slightly dissolved in water. Write both word and chemical equations for the reaction that took place.

c) Suggest with reason(s) why carbon dioxide gas produced from the flask was passed into a wash bottle of:

(i) Distilled water.

(ii) Concentrated Sulphuric acid.

d) Write both word and chemical equations for the reaction between calcium carbonate and dilute hydrochloric acid.

13.5.1. Physical properties(Suitability) of Carbon dioxide gas

- It's a colourless gas, with no Odour (smell)
- It turns moist blue litmus paper red, indicating it is an acidic oxide.
- Does not support burning, hence suppresses combustion.
- Is slightly soluble in water forming weak carbonic acid
- Is denser than air, hence it displaces air downward when collected in a gas jar.

13.5.2. Uses of Carbon dioxide gas

-Carbon dioxide is used as a preservative in the food industry. It aims at extending the shelf-life of perishable foods by inhibiting the growth of bacteria and molds

-Carbon dioxide is used as fire extinguishing agent especially where water – based extinguishers could damage sensitive equipment, such as electric or computer rooms

-Dry ice carbon dioxide is extremely cold (it freezes at-78.5^{0}C and sublimes into gas) upon gaining enough heat. This makes it suitably used as refrigerant for cooling foods and drinks.

-Carbon dioxide is used in bread and cake baking. It makes the dough to rise and expand.

-Carbon dioxide is a raw material used by green plants to make their own food through photosynthesis.

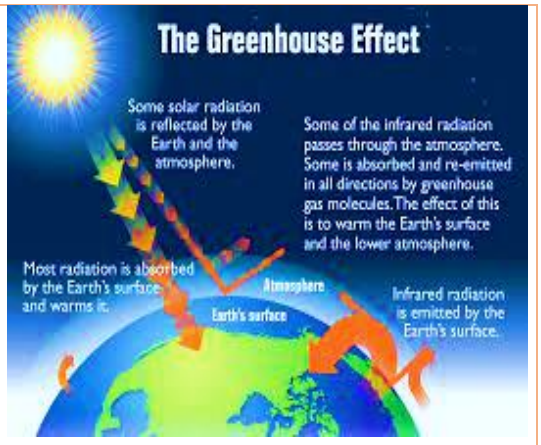
13.6. GLOBAL WARMING AND GREENHOUSE EFFECT

Global warming refers to a state of increased atmospheric and sea – level temperatures above normal as a result of high levels of greenhouse gases in the atmosphere.

Greenhouse Gases: These are atmospheric gases that have the ability to trap, absorb and emit heat radiation from the sun into the Earth's surface. They act as a natural "blanket" that keeps the Earth's surface warm.

Examples of greenhouse gases include: Carbon dioxide gas, **CO_2**, Methane, **CH_4**, Nitrogen oxides (such as nitrogen monoxide, **NO**, nitrogen dioxide **NO_2** and nitrous oxide, **N_2O**) and Sulphur dioxide gas, **SO_2**.

13.6.1.How greenhouse effect causes global warming



Greenhouse effect is a natural process that occurs when greenhouse gases such as carbon dioxide, methane, and water vapour trap, absorb and emit heat radiation from the sun, keeping the Earth's surface warm enough to support life.

However, due to increased human activities such as burning of fossil fuels, deforestation, poor land – use changes have increased the concentration of these gases in the atmosphere.

This leads to an enhancement in the atmospheric and sea level temperatures above normal. The greenhouse gases, absorb and emit infrared radiation into the Earth's surface and atmosphere and sea level, which trap and prevent them from escaping back into the space, leading to global warming.

13.6.2. Possible mitigations on the side effects of global warming

To mitigate the side effects of global warming and to reduce greenhouse gas emissions, several measures have to be taken:

(i) Encouraging shift from the use of fossil fuels to renewable fuels such as solar, hydropower and other forms of renewable energy sources for electricity generation and transportation, since their use does not emit greenhouse gases.
(ii) Promoting and encouraging the use of trains, electric vehicles and public transport means among others to reduce total dependence on fossil fuels.
(iii) The carbon and Sulphur capture and storage technologies should be encouraged to reduce on high emissions of carbon dioxide and Sulphur dioxide gases from industries and automobiles.
(iv) Encouraging and educating the people to implement sustainable land use practices such as reforestation, conservation of natural resources.
(v) Encouraging the use of bioenergy with carbon capture and storage system.
(vi) Establishing international cooperation and global climate governance, policies, agreements and framework to address the global nature of climate.

13.7. HARDNESS OF WATER

		
Rain water	**Tap water**	**Borehole water**

Hardness of water can be further grouped into **soft** and **hard** water.

Soft water: a type of water that forms lather readily with soaps while **hard water** does not form lather readily with soaps. Hard water unlike soft water, contains high levels of dissolved **calcium** and **magnesium** ions that cause scaling, scum builds up, prolong boiling of water and forms scum with soaps.

Scum is an insoluble salt formed when soap react with magnesium or calcium ions in hard water. Hard water is divided into two categories, which include the following:

a) Temporary hardness: is a type of hardness caused by the presence of dissolved magnesium or calcium hydrogen carbonate in water. This type of hard water, can be removed by boiling the water.

b) Permanent hardness: Is a type of hardness caused by the presence of dissolved magnesium or calcium sulphate in water. This type of hard water, cannot be removed by boiling the water.

13.7.1. How temporary or permanent hardness of water is formed.

Temporary hardness of water is formed, when rain water dissolves carbon dioxide in the atmosphere, forming dilute carbonic acid.

Carbon dioxide +Water $\rightleftharpoons$ **Carbonic acid**

$CO_2(g) + H_2O(l) \rightleftharpoons H_2CO_3(aq)$

When this acid water passes through rocks containing calcium carbonate or magnesium carbonate, some parts of it dissolves to form calcium hydrogen carbonate or magnesium hydrogen carbonate, which is responsible for temporary hardness of water.

Word Equations

Calcium carbonate + Carbonic acid $\longrightarrow$ Calcium hydrogen carbonate

Magnesium carbonate + Carbonic acid ⟶ Magnesium hydrogen carbonate

Chemical Equations

$$CaCO_3(s) + H_2CO_3(aq) \longrightarrow Ca(HCO_3)_2(aq)$$

$$MgCO_3(s) + H_2CO_3(aq) \longrightarrow Mg(HCO_3)_{2(}aq)$$

Permanent hardness is a type of water formed when rain water passes through the rocks containing calcium sulphate or magnesium sulphate, parts of them dissolve to form permanent hardness of water.

13.7.2. Methods of softening (removing) Hardness of water

1.Temporary hardness of water can be removed by the following methods

a) Boiling. It decomposes calcium hydrogen carbonate or magnesium hydrogen carbonate to insoluble calcium carbonate or magnesium carbonate respectively. The insoluble carbonate is then filtered off leaving water soft.

Calcium hydrogen carbonate ⟶ Calcium carbonate + Water + carbon dioxide

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

Magnesium hydrogen carbonate ⟶ Magnesium carbonate + Water + carbon dioxide.

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

b) Addition of slake lime (Calcium hydroxide)

Specific quantity of calcium hydroxide is added to temporary hardness of water to precipitate out calcium carbonate from calcium hydrogen carbonate followed by filtration.

Word Equation

Calcium hydroxide + Calcium hydrogen carbonate ⟶ Calcium carbonate + Water.

$$Ca(OH)_2\ (aq) + Ca(HCO_3)_2\ (aq) \longrightarrow 2CaCO_3\ (s) + H_2O\ (l)$$

13.7.3. Methods that remove both temporary and permanent hardness of water

a) Distillation: This method removes all hardness where water is boiled to formed steam which on condensation forms pure and soft water, leaving the impurities as residues.

b) Washing soda (sodium carbonate): Addition of washing soda, precipitates out Magnesium and calcium ions from hard water, followed by filtration. Though this

method is not recommended for human consumption, since it forms alkali solution from its hydrolysis.

c) Sodium Aluminium silicate (sodium – Permutit, Na_2Y): This method works on the principle of ion exchange, where the calcium ions or magnesium ions are exchanged with Permutit to form soft and pure water.

Word Equations

Magnesium + sodium ⟶ Magnesium + Sodium.
Sulphate Permutit Permutit Sulphate

Word Equation

Magnesium hydrogen + sodium ⟶ Magnesium + sodium
Carbonate Permutit Permutit bicarbonate

Chemical Equations

$$MgSO_{4(aq)} + Na_2\text{-}Y_{(aq)} \longrightarrow Mg\text{-}Y_{(s)} + Na_2SO_{4(aq)}$$

$$Mg(HCO_3)_{2(aq)} + Na_2\text{-}Y_{(aq)} \longrightarrow Mg\text{-}Y_{(s)} + 2NaHCO_{3(aq)}$$

ACTIVITY:13.9 Scientific investigation

What you need

Tap water, rain water (distilled water), borehole water, pond water, soap solution, 4 measuring cylinders, conical flasks, burette, coke stoppers, retort stand, filter funnel and stop watch.

What to do

In groups, carry out the following investigations and use it as a basis to determine the volume of the soap solution used in each water source provided.

Treat your experiments as follow

Experiment	Activity
	(i) Place the clean burette up on the retort stand and clamp it firmly. Fill it with soap solution. **(ii)**Obtain 10cm^3 of water sample A into a clean conical flask. **(iii)**Run down 1cm^3 of the burette content into the conical flask. Shake it gently to see if lather is formed. Note and record the final volume of burette contents used for the lather to be formed.

	NB: If lather does not form readily, run again 1cm^3 of the burette content until lather is formed on vigorous shaking of the flask. **(iv)**Rinse your conical flask with clean water.
B	Repeat procedures (ii) to (iv) in experiment **A** using water samples **B** for rain water, **C** for borehole water until consistent final volume of soap solution used in the formation of lather

Discussion Questions

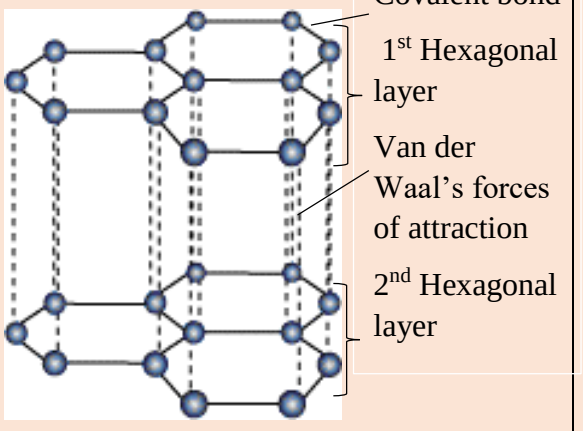
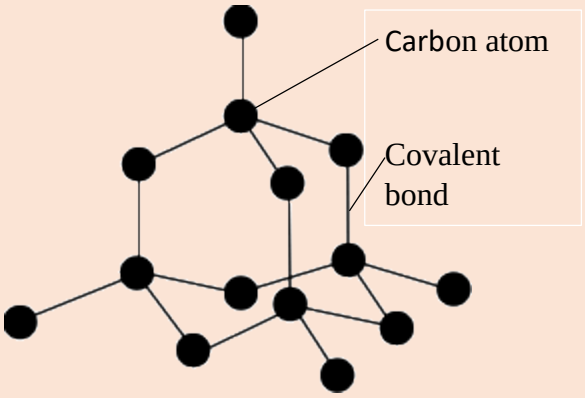
a) Complete the table below for the table of results

Water sample	**Volume of soap solution used**		
	Initial volume (cm^3)	**Final volume (cm^3)**	**Volume of soap solution used (cm^3)**
A			
B			
C			

a) Which of the water samples A, B, C, and D provided used:
(i) Less volume of soap solution
(ii) More volume of soap solution. (iii) Very little volume of soap solution.
b) Name the sample(s) of water that forms (i) soft water (ii) Hard water.

13.8. ALLOTROPY OF CARBON

Allotrope: Refers to the existence of two or more different forms of the same element without change in their physical states. Graphite and diamond are the major forms of allotropes of carbon.

GRAPHITE	**DIAMOND**
	
Structure of graphite	**Structure of Diamond**

In carbon graphite, only three carbon atoms are bonded to one carbon atom by strong covalent bond to form a giant atomic structure of **two-dimensional** crystalline solid layers of hexagonal rings of carbon atoms. The hexagonal layers are held together by weak Van der Waal's forces of attraction.	In carbon diamond, four carbon atoms bonded to one carbon atom by strong covalent bond to form a **giant three – dimensional tetrahedral** structural crystalline solid. The interlocking network of strong covalent bonds, makes diamond to be the hardest material ever known on Earth.

Physical properties (Suitability) of Graphite that determine its uses

1. Graphite is a good conductor of heat and electricity; because each carbon atom in the layers uses only three of its four electrons, leaving one electron which is free to move and conduct heat and electricity.
2. Graphite is soft, slippery and greasy; this is due to the presence of weak Van der Waal's forces of attraction between the hexagonal layers. Making it suitably used for making pencil leads.
3. Graphite is slippery with high melting point, suitably used as lubricants in dynamos, electric motors,
4. Graphite's density is $2.22gcm^3$ lower than diamond, due to the gaps between the hexagonal layers.
5. Graphite is a dark -grey, opaque crystalline solid at room temperature, suitable for making lead pencils.

Uses of graphite	Reason for the choice of use.
(i) It is used to make pencil leads	Because it is soft, slippery and greasy; due to the presence of weak Van der Waal's forces between the hexagonal layers
(ii) It is used as lubricant in dynamos, electric motors.	Because it is slippery and has high melting point
(iii) It conducts both heat and electricity	Because it has free delocalized (mobile) electrons

Physical properties (Suitability) of Diamond that determine its uses

1. Diamond is a poor conductor of heat and electricity; because lacks a free mobile electron, making it unable to conduct heat and electricity.
2. Diamond is the hardest material ever known on Earth, due to the interlocking networks of strong covalent bonds. This makes to be used for cutting, drilling, grinding, smoothening and polishing other hard materials.
3. Diamond's density is $3.53gcm^3$ higher than graphite, due to close packing in the carbon atoms in the structure.

4. Diamond is a transparent crystalline solid at room temperature.
5. Diamond has a high refractive index (sparkling and reflective appearance) when polished. This makes it suitable for making jewelries such as necklaces, bracelets, earrings.

Uses of Diamond	Reason for the choice of use
(i) It is used as the hardest material for cutting glass, drilling, grinding, polishing and smoothening other hard materials.	Due to the presence of interlocking networks of strong covalent bonds
(ii) It is used for making jewelries such as necklaces, bracelets and earrings	Because it is transparent crystalline material, with a high refractive index when polished

13.9. Sample Activity of Integration

Scenario:

There is a growing global problem in the rates at which vegetation are being cut down with intention of getting wood and charcoal for home and commercial cooking. It is as if this is not enough, many human activities have resulted into production of greenhouse gases, greenhouse effect that cause global warming.

You school is organizing a school day sensitization where all parents of your school will be invited on that day. Your Head teacher, wants the parents and the rest of the entire schools to understand the impact of human activities and use of carbon – based fuels in our day – to – day life activities.

Task:

The Head of chemistry department, selected you to prepare a written report, which you will deliver on that day.

13.10. End of Chapter 13 Summary

1. Carbon is one of the most successful and abundant elements on Earth. It exists in three forms of allotropes, pure crystalline forms (graphite and diamond) and impure amorphous form (carbon such as charcoal, lamp – black, coke and coal)
2. Energy sources include renewable and non -renewable fuels. Non – renewable fuels are mainly carbon – based fuels such as crude oils, coal, charcoal, fire wood whereas renewable fuels are non – carbon-based fuels such as solar, wind, hydropower, Geothermal energies. Renewable fuels are sustainable to the environment compared to non – renewable fuels.
3. Combustion of carbon -based fuels in limited or plenty supply of oxygen increases the concentration of carbon monoxide, carbon dioxide gas, nitrogen dioxide gas and Sulphur dioxide gas in the atmosphere causing greenhouse effect and global warming.

2) The use of charcoal as a cheap source of fuel is efficient and sustainable if it is well managed by obtaining them only from wood or trees that are easy to replant. Cut one tree, replace the cut ones by replanting more trees, in this way charcoal will be sustainable since it leaves the environment with minimum effect.

3) Fuel is a substance or material which when burnt in oxygen, produces light and heat as a major product.

4) Carbon dioxide gas dues not support combustion, it neither burns nor supports burning. It suffocates burning, a condition known as fire extinguishers.

5) Global warming refers to a state of increased atmospheric and sea – level temperatures caused by high level of greenhouse gases. Such gases include carbon dioxide, Sulphur dioxide, methane, water vapour, nitrogen oxides. Global warming is enhanced by human activities such as burning of fossil fuels, industrial activities, deforestation, urbanization, and transport – motorists.

(ii) **Greenhouse gases**. These are atmospheric gases that have the ability to trap, absorb and emit solar radiation from the sun into the Earth's surface. They act like a natural "blanket" of warmth around the Earth. Examples of greenhouse gases include: Carbon dioxide gas, Methane (CH_4), Nitrogen oxides (such as nitrogen monoxide, NO, nitrogen dioxide NO_2 and nitrous oxide, N_2O) and Sulphur dioxide gas.

1. Water hardness is a condition of soft and hard water to form lather readily with soap. Soft water: Is that water which forms lather easily with soap. Hard water: Is that water which does not form lather easily with soap. It can be temporary and permanent hard waters. Hard water is caused by two cations, magnesium ions, Mg^{2+} and calcium ions, Ca^{2+}.
2. **Allotropy**: Refers to the existence of two or more different forms of the same element in the same physical states. These elements are called allotropes, examples are Carbon – graphite, Carbon – diamond and amorphous carbon.