CHAPTER IV

DEVELOPMENT OF TOOLS
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For the purpose of the present study, following tools were developed by the investigator herself for local use:

(i) Objective-based curriculum on three topics selected from X Class Science Syllabus of Punjab School Education Board.

(ii) Achievement test on the topics selected.

(iii) A Process Skills Test to measure the acquisition of process skills.

The development of achievement test and process skills test are detailed in Chapters Fifth and Sixth respectively. The development of objective-based curriculum is discussed in this chapter.

The various steps followed in the preparation of this curriculum include (i) selection of units, (ii) deciding initial behaviours, (iii) defining appropriate objectives in behavioural
DESIGNING OF OBJECTIVE BASED CURRICULUM:

Selection of Unit: In the selection of units, the size of unity, the general objectives and specific objectives of instructions were kept in view. Following three units were selected for developing objective-based curriculum:

- Carbon and its allotropic forms.
- Compounds of carbon -carbon dioxide ($CO_2$), and carbon-monoxide (CO).
- General characteristics of metals and non-metals.

The utility and difficulty faced by X class students in learning these units were the main criterion of the selection for the units.

Since the developed material was intended for the X grade science students it was assumed that they had initial level of knowledge of chemistry upto IX grade and that they could understand the material written in Punjabi language. With a view to ensure their level of knowledge in chemistry and possession of process skills, they were given the respective tests, to assess their previous knowledge required to understand the developed curriculum and the initial acquisition of skills required to develop the chosen skills.
It was ensured from the concerned teachers that the students had not already studied the topics selected for the purpose of present study.

Initial Behaviours of the Learner: The major contribution that curriculum development has made to educational practice is obvious from the emphatic insistence on the importance of instructional objectives in behavioural terms. Tyler (1932) stressed the need to define objectives in behavioural terms. The same was supported by Bloom's Taxonomy of Educational Objectives and Task Specifications. The success of a curriculum depends upon a clear identification of initial behaviours and realisation of terminal behaviours in the learner. These objectives in behavioural terms also help in deciding as to where from start the curriculum and where to end it.

Mager (1962) defined an objective as "The intent communicated by a statement describing a proposed change in a learner - a statement of what the learner is likely to be when he has successfully completed a learning experience. It is a description of a pattern of behavioural performance we want the learner to be able to demonstrate". The defining of objectives in behavioural terms provides guidance for selecting appropriate material and instructional procedures to be followed as also provides criterion for the evaluation of the learning outcomes.
Mager (1962) has further distinguished between pre-requisites, course description and objectives. Pre-requisites account for what a learner has to be able to do to qualify for a course; Course description means as to what the course is about and objectives relate to as to what a successful learner will do at the end of a course.

Mager's recommendations were accepted as guidelines for writing the behavioural objectives in the present study. The terminal behaviours as evidence that the learner has achieved the objective was identified by name, the important conditions under which the particular behaviour will occur were described, criteria of acceptable performance were specified by describing how well the learner must perform to be considered acceptable. Besides, these objectives were written in a clear language, they were specific in nature and achievable in specific time with the content, learning activities and method to be used for achieving them. The unit-wise educational objectives in behavioural terms are as given below:

**Educational Objectives in Behavioural Terms:**

**Unit I**

**Carbon and its allotropic forms**

(A) Knowledge Objectives:

The student will -

1. identify the symbol of carbon and its Atomic weight.
2. tell the state in which carbon occurs in nature.
3. tell the names of free and combined states of carbon.
4. describe the sources of carbon.
5. classify the different forms of carbon into crystalline and amorphous carbon.
6. describe the history of diamond, preparation of artificial diamond and properties of diamond.
7. tell the names of the places in the world where diamonds occur.
9. describe the preparation of charcoal and animal charcoal.
10. tell the method of preparation of lamp black and percentage of carbon in it.

(B) Comprehension Objectives:
The student will -
1. explain the allotropic property of carbon.
2. give reason for the use of graphite as a lubricant in heavy machinery and for making electrodes.
3. explain the floating property of charcoal.
4. define destructive distillation of coal and charcoal.
5. explain the meaning of chemical identity.

(C) Application Objectives:
The student will -
1. give uses of diamond, graphite, coal, charcoal, animal charcoal, coke, gas carbon and lamp black.
2. give examples of allotropic elements other than carbon and write their different allotropic forms.
(D) Process Skills Objectives:

The student will -

1. observe and write properties of coal and charcoal.
2. observe the decolourization of coloured solution by the addition of charcoal or animal charcoal powder to it, then by boiling and filtering it and give reason for decolourization of the solution.
3. reason out why red hot charcoal sinks in water while charcoal floats over it.
4. write what he observes, while performing the experiment to prove the adsorbing property of charcoal.
5. prove that coal, charcoal and lampblack produce carbon-dioxide on burning in air.

Unit II
Compounds of Carbon

(A) Knowledge Objectives:

The student will -

1. tell history of carbon-dioxide and the sources from which carbon-dioxide is obtained.
2. describe that carbon-dioxide gas can be liquified and solidify and solid carbon-dioxide is called dry ice.
3. tell history of carbon-monoxide.
4. write properties of carbon-monoxide that it is colourless poisonsness, tasteless gas having light smell.
5. tell the percentage of carbon-dioxide by volume in air.
6. recall the name of gas filled in soda water, names of the reactants and products of photo-synthesis.
7. recall the chemical names of carbonic compounds like washing soda, baking soda.
8. tell the use and composition of carbose.
9. recall the name of chemicals used in fire-extinguisher.
10. tell that plants and animals produce carbon-dioxide during respiration and green leaves produce oxygen during photo-synthesis.
11. recall the properties of carbon-dioxide that it turns lime water milky, which again becomes clear when the gas is continuously passed through it.

(B) Comprehension Objectives:
The student will -
1. define photo-synthesis.
2. describe carbon-dioxide cycle in nature.
3. explain the preparation of dry ice.
4. explain the functioning of fire extinguishers.
5. explain the methods of preparation of carbon-monoxide.
6. describe the formation of carbon-dioxide and carbon-monoxide in coke oven.

(C) Application Objectives:
The student will
1. give uses of carbon-dioxide.
2. tell that during night, plants do not produce oxygen but they continue respiring, hence leaving carbon-dioxide.
3. give examples in daily life e.g. smoke coming out of chimneys of the factories, formation of carbon-dioxide and carbon-monoxide in stove.

4. recall uses of carbon-monoxide.

5. explain why we should not burn coals in closed sleeping room.

(D) Process Skills Objectives:

The student will:

1. prepare carbon-dioxide gas in the laboratory and apply all precautions needed to be used during the preparation of gas.

2. prove that germinating seeds produce carbon-dioxide during respiration.

3. notice the problems e.g. slow evolution of gas from the apparatus, changes in colour of lime water when carbon-dioxide is passed, shifting of pointer of the balance when carbon-dioxide is poured in beaker placed in balance.

4. write the physical properties which he observes of carbon-dioxide.

5. prove the acidic nature of carbon-dioxide.

6. identify carbon-dioxide.

7. write conclusions of the experiments performed in the laboratory.

8. solve the problems (as told in number three).

9. note the formation of blue coloured gas in the lower part of the candle flame and prove it as carbon-monoxide.

10. represent graphically carbon-dioxide cycle in nature.
Unit III
General Characteristics of Metals and Non-metals

(A) Knowledge Objectives:
The student will -
1. tell that elements have been divided in metals and non-metals.
2. recall general characteristics of metals and non-metals.
3. recall the metallic properties of non-metals like lustre and conductivity of graphite, hardness of diamond.

(B) Comprehension Objectives:
The student will -
1. classify Antimony and Arsenic as metalloid.
2. explain the basis of classification of elements.
3. classify graphite and gas carbon as non-metal and tell that both are good conductors of electricity.
4. identify hydrogen as non-metal although it is electronegative.
5. define mineral, ore and metallurgy.
6. explain properties of alloys.
7. explain the phenomena of corrosion.

(C) Application Objectives:
The student will -
1. give examples of metals and non-metals.
2. give examples of metalloids.
3. give examples of electropositive elements and elements which are good conductors of heat and electricity.
4. Give example of non-metal with metallic lustre.
5. Tell the constituents of sodium amalgam.
6. Explain the purposes of making alloys.
7. Recall uses of alloys like, nickle steel, solder, bronze, brass, aluminium bronze, etc.
8. Explain the reason for which acidic eatables (curd) should not be kept in copper utensils.

(D) Process Skills Objectives:
The student will-
1. Write the physical characteristic of given metals and non-metals.
2. Make comparison of physical characteristics (state, lustre, hardness, opaqueness, ductility, malleability, conductivity, production of sound) of given metals and non-metals.
3. Find that magnesium produces hydrogen with dil. acids.
4. Observe piece of rusted iron and conclude that Iron forms Iron oxide by reacting with oxygen of the air.
5. Observe that zinc dissolves in conc. sulphuric acid.
6. Notice non-metals (carbon, sulphur) produce neutral oxide or acidic oxide (carbon-dioxide and sulphur dioxide on reacting with oxygen).
7. Observe that metals (zinc and iron) do not react with dil. acids.
8. Observe that non-metals e.g. sulphur, dissolve without chemical action in carbon-disulphide.
Carbon is one of the most important elements on this earth and known in various forms, such as coal, charcoal and diamond since very early times. In 1775, Lavoisier proved that diamond like charcoal is a form of carbon and gives carbon-dioxide on burning. In 1800, Mackenzie showed that graphite is also a form of carbon. Carbon occurs abundantly in the free and combined state. In the free state it occurs as: (1) diamond and graphite (crystalline) forms, (ii) coal, charcoal, bone-coal etc, (amorphous) forms. In the combined state, it occurs as,

(i) carbon-dioxide to the extent of 0.03 per cent in air.
(ii) carbonates such as chalk, marble, limestone, magnesite, dolomite.
(iii) as hydrocarbon in petroleum and natural gas.
(iv) as an essential part of all animal and vegetable life in the form of fats, proteins and carbohydrates.

Allotropic forms of carbon:

(i) **Diamond** - It is the most beautiful and the costliest of all gems. It occurs in South Africa, Brazil, Australia and India. South Africa supplies 96 per cent of world production
Properties of Diamonds:

(a) It is transparent substance which may or may not have a colour.
(b) It is hardest substance known and can cut even glass.
(c) It has a high refractive index of 2.45 and its density is 3.51.
(d) It is a bad conductor of heat and electricity.
(e) On heating strongly at 1000°C in oxygen, it burns giving carbon-dioxide.
(f) It neither melts nor gets transformed into vapours.
(g) When heated strongly in the absence of air, it gets transformed into graphite.

(2) Graphite - It occurs in Ceylon, Siberia, Canada, India and U.S.A.

(3) Coal - It is complex substance consisting of compounds of carbon, hydrogen, oxygen, nitrogen and some free carbon. It is formed by the slow decomposition of vegetable matter of the remote past under earth due to high pressure and temperature in a limited supply of air. Coal occurs enormously in India, coal fields are found in Bengal, Bihar, Assam, Orrisa, Andhra Pradesh and Madhya Pradesh.
Coke: It is residue left in the retort after the destructive distillation of coal for the manufacture of coal gas. It is pure form of carbon that contains 80-90% of carbon in it. Gas carbon is pure form of carbon and is formed as a hard deposit on the roofs and the sides of the retorts during the destructive distillation of coal.

Charcoal: It is obtained by heating wood in the absence of air.

Animal Charcoal: It is obtained by destructive distillation of animal bones. It contains mainly calcium and phosphate and only about ten percent of carbon.

Lamp black: It is amorphous form of pure carbon and contains 98.6% of carbon.

Preparation of Artificial Diamonds:

In nature, diamonds are supposed to be formed due to crystallisation of carbon from its solution in molten iron. On this ground, Moissan, in 1893, obtained diamonds artificially in very small size. He dissolved sugar charcoal in molten iron at 3500°C. The fused mass was then plunged in molten lead at 327°C. The outer surface of iron cooled and solidify and expand exerting enormous pressure. When cold, iron was dissolved away with dil. hydrochloric acid, tiny crystals of diamond and some graphite were left behind.
Manufacture of Graphite:

A charge consisting of coke and a little sand is heated in an electric furnace fitted with two carbon electrodes connected by thin carbon rods known as carbon core. A strong alternating current is passed through the mass for about thirty-six hours when the temperature rises to about 3500°C. Silicon carbide is formed which decomposes to give graphite and silicon. Silicon volatilizes off due to very high temperature and graphite is left behind.

Manufacture of Charcoal:

(i) Small logs of wood are piled up with air space in the middle to act as chimney. A number of small holes are left at the bottom. The piled is covered with earth and fired by dropping a burning log of wood down the chimney. The wood is allowed to burn slowly in a limited supply of air entering from holes. After a few days, the holes are closed and the charcoal formed is allowed to cool. About twenty-five percent of wood changes into charcoal.

(ii) In the modern process, wood is destructively distilled i.e., heated strongly in the absence of air. The residue in the iron retorts is wood charcoal.

Manufacture of Lamp Black:

Carbon rich substances (oil, wax) are burnt in big rooms and the smoke thus formed is taken to another room where revolving
drums full of water are placed. The smoke gets deposited in the form of lamp black.

In the Laboratory, it is obtained by destructive distillation of wood.

Coal is formed by the slow decomposition of vegetable matter of the remote past under earth due to high pressure and temperature in a limited supply of air. This process of slow decomposition took centuries to complete and different forms of coal, perhaps represent the sub-stages during the coal formation. Peat represents the first stage of the transformation of vegetable matter to coal. It is loose and light variety and contains about sixty percent carbon. Lignite, Bituminous and Anthracite represent the second, third and last stage respectively. They contain 70%, 83% and 90% carbon respectively.

Comprehension:

**Allotropy** - It is property of an element in which it exists in two or more forms which have different physical properties but same chemical properties. A substance which shows this property is called allotropic.

**Destructive Distillation of Coal**:

The process in which coal is heated strongly in the absence of air to obtain different products is called destructive distillation of coal.
Adsorption: The charcoal has property of fixing up gases on its surface. This property is called adsorption.

Chemical Identity: When a known weight of different allotropic forms of carbon is burnt in oxygen they form exactly the same quantity of carbon-dioxide. This property is known as chemical identity of carbon.

Chemical Properties of Carbon: (i) All forms of carbon though physically different are chemically identical. All forms of carbon burn in air or oxygen to form carbon-dioxide. On burning in limited supply of oxygen, they form carbon-monoxide.

(ii) Reducing property - On account of its affinity for oxygen at high temperatures, it acts as a reducing agent. It reduces certain metallic oxides to their metals, e.g.

(a) Copper oxide + Carbon → Copper + Carbon-monoxide.
(b) Zinc oxide + Carbon → Zinc + Carbon-monoxide.
(c) Lead oxide + Carbon → Lead + Carbon-monoxide.

(B) Sulphuric acid and nitric acid are reduced to sulphur dioxide and nitrogen peroxide respectively.

(i) Carbon + Sulphuric acid → Carbon-dioxide + Sulphur dioxide + Water.
(ii) Carbon + Nitric acid → Carbon-dioxide + Nitrogen peroxide + Water.

(C) Water is reduced to hydrogen forming water gas.

Carbon + Water (Steam) → Carbon-monoxide + Hydrogen

Water Gas
(D) Sulphates are reduced to sulphides.

Sodium Sulphate + Carbon — Sodium Sulphide + Carbon-monoxide.

(iii) Combination with Sulphur: It combines with sulphur-vapours at high temperature forming carbon-disulphide.

(iv) It combines with hydrogen at the temperature of electric arc (1000°C) to give acetylene.

\[ \text{Elec.} \quad \text{Carbon + Hydrogen} \rightarrow \text{Acetylene.} \]

(v) Formation of Carbides: In an electric furnace, oxides of calcium, silicon and aluminium give carbides with carbon.

\[ \text{Calcium Oxide + Carbon} \rightarrow \text{Calcium Carbide + Carbon-monoxide.} \]

\[ \text{Carbon + Silicon-dioxide} \rightarrow \text{Silicon Carbide + Carbon-monoxide.} \]

Carbon forms innumerable compounds with elements like hydrogen, oxygen, Nitrogen and halogens. They are called organic compounds.

**Application:**

**Uses of Diamond:** It is used for cutting glass, for drilling of rocks.

**Uses of Graphite:** It is used in making lead pencils, as a lubricant in heavy machinery, for making electrodes, for making crucibles, after mixing with clay and in electroplating.
Uses of Coal: Coal is mostly used in engines, kilns and steam boilers. It is also used for the manufacture of coal gas, producer gas and water gas. Synthetic petrol is also obtained from it. Ammonia is obtained from Ammonical compounds obtained from coal. Coal tar is obtained from coal which is used in the preparation of many carbonic compounds, phenyl, benzene etc.

Uses of Coke: It is used in metallurgical operations and for the preparation of fuel gases.

Gas carbon, which is good conductor of electricity, is used in making electrodes.

Uses of Charcoal: (i) It is used for decolorising solutions.
(ii) It is used in gas masks, which saves us from poisonous effect of gases.
(iii) It is used in the distillation of water because it kills germs.
(iv) Wooden blocks are slightly burnt before keeping them underground because charcoal has no effect of moisture.
(v) Charcoal is used in tooth-powders.
(vi) Used as a fuel.

Uses of Animal Charcoal: (i) It is used in the refining of sugar.
(ii) For the preparation of phosphorous.
(iii) For decolourising organic substances.
Allotropic forms of Sulphur and Phosphorous: Phosphorous and sulphur exist in several allotropic modifications. They are as follows:

Allotropic forms of Sulphur:
1. Rhombic or octahedral sulphur.
2. Monoclinic or prismatic sulphur.
4. Milk of sulphur.
5. Colloidal sulphur.

Allotropic forms of Phosphorous:
1. White phosphorous.
2. Red phosphorous.

Process Skills:

Properties of Graphite:
(i) It is greyish black, soft crystalline solid with a metallic lustre and a soapy touch.
(ii) Good conductor of heat and electricity (Density 2.2).
(iii) On heating strongly in air, it burns giving carbon dioxide.
(iv) It is not acted upon by dil acids or alkalies.
(v) It marks the paper.
(vi) It is infusible.

Expt.: Heat some wood chips in a hard glass tube (as shown in the diagram). On strong heating, wood changes into charcoal and the following products are obtained:
(i) Wood gas (combustible gas).
(ii) Tar.

Properties of Charcoal:
(i) It is a black porous substance.
(ii) Bad conductor of heat and electricity.
(iii) Floats on water due to air present in the pores.
(iv) It burns in air to form carbon-dioxide.
(v) Moisture has no effect on it.

Properties of Animal Charcoal:
(i) It is black porous substance.
(ii) It absorbs the colour of the solutions.
(iii) On burning in air, it gives carbon-dioxide.

Preparation of Lamp Black: Burn Mustard oil in burner and keep Iron plate over the smoke. Remove the Iron plate after twenty minutes. Collect the soot deposited over the Iron plate.

Properties:
(i) It is soft black powder.
(ii) It forms carbon-dioxide on burning.

Destructive Distillation of Coal: Take some powdered coal in a hard glass tube and fit it as shown in diagram. Heat the glass tube. On strongly heating, following products are formed.
(i) Gas carbon gets deposited on the wall of the test tube.
(ii) Coke - residue left on the base of the test tube.
(iii) Coal gas collected in gas jar.
(iv) Coal tar - forms the lower layer of standing tube.

To produce all these products in big quantity, coal is heated in big iron retorts.

**Properties of Coal:**

(i) It is black, hard and heavy substance.
(ii) On heating in air, it burns with difficulty but when burnt gives strong heat.
(iii) On heating in the absence of air, it produces coal gas, compounds of ammonia, coal tar, coke and gas carbon.

**Properties of Coke:**

(i) It is hard porous substance.
(ii) It burns without smoke and gives heat in sufficient amount.
(iii) It is brownish-black in colour.
(iv) On burning, it gives carbon-dioxide.

**Expt. (i)** Take two-three pieces of charcoal and put them in water contained in a beaker. They will float on water. Take another pieces of red hot charcoal and put them in water. They will sink in the water because on heating air is expelled from the pores and water gets filled in them.

**Expt. (ii)** Take red coloured solution in a beaker and put powdered charcoal in it. Boil it and filter it. The filtrate
will be colourless. Charcoal has the property of fixing up gases, liquids due to absorption of colouring matter on its surface.

Expt. (iii) Take Mercury in a small tube. Invert jar full of Ammonia gas over it. Keep burning charcoal piece beneath the jar. Because it is lighter than mercury, charcoal will rise up in jar and will adsorb ammonia gas there. As a result, Mercury Level will rise up in the jar.

Expt. (iv) Put some powdered animal charcoal in solution, boil it and cool it. Filter it. The filtrate will be colourless. Animal charcoal like wood charcoal has the property of adsorbing colouring matter.

Expt. (v) Heat small quantity of sugar in test tube and test the gas evolved with lime water. The lime water turns milky. Repeat the above experiment by taking cotton, wheat powder and benzene respectively and test the gas evolved in every case with lime water. Everytime lime water turns milky, why? Carbon compounds on heating in air give carbon-dioxide.

CONTENT UNIT - II
Compounds of Carbon
(Carbon-dioxide and Carbon-monoxide)

Knowledge:
Carbon-dioxide has been known since long. Black (1755)
called it fixed air as it occurs in a fixed form in carbonates. Levoisier proved it to be an oxide of carbon. It occurs in air to the extent of 0.03 percent by volume. It is present in air due to combination of fuel, respiration of animals, decay of animals and plants and fermentation. It also comes out of volcanic caves, e.g., valley of death in Java. In combined form it occurs as carbonates. Carbonates and bicarbonates of non-alkali metals on heating give carbon-dioxide.

\[ \text{Copper Carbonate} \xrightarrow{\Delta} \text{Copper Oxide} + \text{Carbon-dioxide} \]

The carbonates of sodium and potassium metal do not react on heating.

Comprehension:

Carbon dioxide is present in the atmosphere to the extent of about 3 parts in 10,000 (0.03 per cent by volume) and its presence is of utmost significance to plant and animal life. The structure of both plants and animals consists essentially of carbon-compounds and all the carbon contained therein is derived from the atmosphere. The carbon compounds contained in animals are derived either from plants and eaten by the animals which in turn have consumed plants as food.

Plants take up carbon dioxide during the day through the pores present in their leaves and convert it into carbohydrates
such as glucose, starch and cellulose. The reaction (photosynthesis) takes place in the presence of sun-light and chlorophyle- the green pigment of the plant leaves, acting as a catalyst.

\[
\text{Carbon dioxide} + \text{Water} \xrightarrow{\text{Photosynthesis}} \text{Glucose} + \text{Oxygen}
\]

Oxygen set free returns to the air.

The carbon absorbed by animals is ultimately returned to the atmosphere in the form of carbon-dioxide exhaled by the lungs, while the rest returns by the decomposition of the dead bodies of plants and animals.

Carbon-dioxide is appreciably soluble in water and certain amount of carbon-dioxide has been more or less permanently removed from the air by rain, through the formation by aquatic animals of shells composed of calcium carbonate. This is the origin of the enormous beds of lime stone and chalk which exist in various parts of the world and it is quite probable that this process is still going on.

Fire Extinguishers: The principal of extinguishing a fire is to cut off the supply of air, from the burning material. This may be done by throwing sand, water or carbon-dioxide, water is unable to extinguish oil fires as being heavier than oil it goes to the bottom and spreads the burning oil, causing
more fire instead of extinguishing it. Carbon-dioxide is thrown over the fire from fire-extinguishers which are of three types:

(i) Acid-Soda fire extinguisher :- It consists of strong iron vessel containing conc. sodium-bicarbonate solution conc. sulphuric acid contained in a bottle fitted with a loose stopper is supported inside the vessel. When the apparatus is inverted, the stopper comes out. Carbon-dioxide is produced by the action of sulphuric acid on the bicarbonate and escapes forcibly from the nozzle.

(ii) Formate fire extinguisher :- Here, sulphuric acid is replaced by aluminium sulphate and licorice extract, carbon-dioxide is produced by the action of aluminium sulphate on sodium bicarbonate. Licorice extract forms a viscous fluid which is blown into a foam by carbon-dioxide. This foam sticks firmly to the burning object and quickly puts out the fire by cutting the supply of air. This type of fire-extinguisher is particularly used to put out oil fires because the foam produced floats over the surface of burning oil and is not rendered ineffective like water which sinks to the bottom.

Liquid carbon-dioxide fire extinguisher :- Liquid-carbon-dioxide is taken in a cylinder fitted with a valve and a nozzle, on inverting the cylinder and opening the valve, liquid carbon-dioxide comes out, rapidly gets cooled due to sudden evaporation and solid carbon-dioxide is thrown on the burning object. It is
superior to ordinary type of fire extinguishers in so far as it leaves no dirty residue.

Application:

Uses of carbon-dioxide:

(1) In the preparation of exerated water like Lemonade.
   It comes out when soda water bottle is opened.

(2) In the purification of cane-juice for the manufacture of cane sugar.

(3) As a fire-extinguisher.

(4) For artificial respiration for victims of carbon-monoxide.

(5) As a dry ice in curing local sores.

(6) As a refrigerant in the form of solid carbon-dioxide.

(7) In the manufacture of sodium-carbonate and sodium bicarbonate.

Carbon-dioxide is not poisonous gas but animals die in it due to lack of oxygen. It is harmful to sleep under trees during night hours because plants produced carbon-dioxide and no oxygen as the process of photo-synthesis occurs in sun-light only.

Process Skills:

Laboratory Preparation of Carbon-Dioxide: In the laboratory, carbon-dioxide is prepared by the action of dil. hydrochloric acid on calcium carbonate chips. Calcium carbonate pieces are taken in Woulf's bottle. The apparatus is fitted as shown in the diagram. It is tested, to find whether it is air tight or not. The cork is made air tight either by the use of wax or by
changing it. Dil hydrochloric acid is poured through thistle funnel so that it covers the marble chips and lower part of the funnel. At once, the chemical reaction take place and gas is evolved. First few bubbles are not collected as they contain air of the woulf bottle. The gas is collected in dry gas jars. To see, whether the jar is full of gas or not, take burning splinter at the mouth of gas, if it gets extinguished, the jar is full.

**Precautions**:

1. The apparatus should be air tight.
2. The lower portion of the funnel should dip in the dil acid.
3. Gas should be collected in dry gas jars.
4. Gas should be prepared in open.
5. Gas should not be collected over water as it is soluble in water.

**Properties of Carbon-dioxide**:

(a) Physical Properties:

1. It is a colourless gas with a faint smell.
2. It is slightly soluble in water and dissolve under pressure giving aerated water. The gas solution (aerated water) has sour taste. Keep gas jar inverted over a tub of water. After sometime water level rises up slightly, showing the solubility of gas in water.
Keep a jar full of gas inverted for some time. Take burning splinter near the gas jar's mouth, slightly inside. It keeps on burning showing that gas has gone down towards the bottom and its place is taken by air. Carbon-dioxide is heavier than air.

Though carbon-dioxide is heavier than air, it does not form the lower layer in the atmosphere because of its diffusion property.

**Expt.:- (i)** Place four candles in a row and light them. Pour gas on the candles as water is poured from one vessel to another. The candles are put out by the gas, showing that it flows like water.

**Expt.:- (ii)** Place a beaker in the left pan of the balance and counterpoise it by putting weights in the right pan. Now open a cylinder of carbon-dioxide at the mouth of the beaker. The equilibrium of the beam is disturbed. The movement of the pointer to the right indicates that the carbon-dioxide is heavier than air displaced from the beaker.

(b) Chemical Properties:

1. Combustibility:

   (i) Take burning splinter to the mouth of gas jar. It is extinguished and gas does not burn. Thus carbon dioxide is neither combustible nor a supporter of combustion.
(ii) Take burning Magnesium ribbon in a spoon in a jar of carbon-dioxide. It continues to burn in it. Specks of carbon deposit on the side of the cylinder:

\[ 2 \text{Mg} + \text{CO}_2 \rightarrow 2 \text{Mg} + \text{C} \]

(iii) Take burning sodium piece in a burning spoon in a jar full of carbon-dioxide. It remains burning and specks of carbon deposit on the side of the cylinder.

Active metals (sodium, potassium) separate oxygen from carbon-dioxide, use oxygen for burning and free carbon.

2. Acidic Nature:

Put wet blue and red litmus papers in gas, jar, blue litmus paper is turned red. Red litmus paper is not effected. Dissolve the gas in water, weak-acid (carbonic acid) with sour taste is formed. Carbon-dioxide is therefore also called carbonic anhydride.

3. Action with Alkalies and Lime Water:

Pass carbon-dioxide through lime water. It first gives carbonates and then bicarbonates. Lime water first turns milky due to formation of insoluble calcium carbonate but with the continuous passage of carbon-dioxide, it becomes clear as the insoluble calcium carbonate is changed to soluble calcium carbonate.
Photo-Synthesis:

**Expt.**:- Take a big beaker full of water and dissolve carbon-dioxide in it. Keep some hydrilla plants in a funnel placed inverted in a beaker. Invert a test tube over the funnel and place the whole apparatus in the sun for four five hours. Water comes down the test tube slowly and gas is collected in its place. The gas collected is tested and found to be oxygen.

**Expt.**:- Plant growing in a bell jar decreases the amount of carbon-dioxide and increases the amount of oxygen in the bell jar. A plant and a burning candle are placed beneath a bell jar. The candle burns one minute and then goes out. Three days later, the candle is ignited by means of the electrical apparatus and burns one minute before going out.

Carbon-dioxide cycle in nature:- Huge quantities of carbon-dioxide are being formed constantly as a result of

1. Burning of carbonaceous sustances.
2. Breathing of man and animals.
4. Decay of animal and vegetable matter.
5. Fermentation.

Carbon-dioxide thus produced is consumed by green plants during the process of photo-synthesis. During this process oxygen is produced. Because of these two opposing factors, the percentage of carbon-dioxide remains constant in nature.
**Expt.** :- Take small amount of calcium carbonate in a test tube and heat it. Test the Carbon-dioxide evolved.

**Expt.** :- Take small quantity of sodium bicarbonate in a test tube and heat it. Again, test the gas evolved, the gas will be carbon-dioxide.

**Expt.** :- Take lime water (about 5-6 ml/s) in a small beaker and breath out in it. Lime water turns milky. Take a burning candle and breath out over it.

The candle is extinguished due to outcome of carbon-dioxide during breathing.

**Expt.** :- Take some moist germinating seeds and put them in rubber bottle with cork and rubber tube. Keep it for twenty four hours. Take lime water (small quantity) in a test-tube and pass the gas from the bottle through it. Lime water turns milky showing that plants produce carbon-dioxide during breathing.

**Knowledge :**

Carbon-monoxide was taken as hydrogen for a long time because like hydrogen, it burns with blue flame. It is a poisonous gas having no taste. Its density is 1.4 and it can be liquidified under high pressure and low temperature.

**Comprehension:**

Carbon-monoxide is produced when carbon is heated in
limited supply of air or oxygen. In an coke oven, carbon burns at lower part to give carbon-dioxide. As it rises up, it is reduced to carbon-monoxide by the hot layer of charcoal which burns with blue flame giving carbon-dioxide.

\[ \text{C} + \text{O}_2 \rightarrow \text{CO}_2 \quad \text{(at the base)} \\
\text{CO}_2 + \text{C} \rightarrow \text{2CO} \quad \text{(in the middle)} \\
\text{2CO} + \text{O}_2 \rightarrow \text{2CO}_2 \quad \text{(at the top)} \]

Preparation of Carbon-monoxide:

(a) It is prepared by passing dry carbon-dioxide over red hot coke in an iron tube and collecting the gas over caustic soda.

(b) It is prepared by the action of conc. sulphuric acid on formic acid at 100°C. The gas obtained is sufficiently pure. Sulphuric acid acts as dehydrating agent. It is also obtained from water gas which is mixture of carbon-monoxide and hydrogen. It is prepared from producer gas - a mixture of nitrogen and carbon-monoxide.

Application:

(1) In factories, it is present in the chimney gases on account of incomplete combustion taking place due to insufficient supply of air. In a stove, carbon burns at lower part to give carbon-dioxide. As it rises up, it is reduced to carbon-monoxide, which burns at the top of the stove with a blue flame giving carbon-dioxide.
(2) Carbon-monoxide is highly poisonous gas. A person who inhales it feels giddy and then becomes unconscious and dies. Therefore, it is dangerous to keep coal fire in a poorly ventilated room. An unconscious victim of carbon-monoxide should be taken out in open and given an artificial respiration of a mixture of 95% oxygen and 5% carbon-dioxide.

**Uses:**

1. In the metallurgy of Nickel and Iron.
2. In the manufacture of methyalcohal and formates.
3. In the manufacture of phosgene gas.
4. As a reducing agent.
5. As an industrial fuel in the form of water gas and producer gas.

**Process Skills:**

Laboratory Preparation of Carbon-monoxide. Take improvised Kipp's apparatus. Put conc. sulphuric acid in the bottle and Sodium formate in the test tube as shown in the diagram. Make contact of the acid with sodium formate and note the evolution of colourless gas. Take burning candle near the mouth of the jet tube. What happens? The candle gets extinguished but the gas starts burning with blue flame.

**Precautions:** (i) Since the gas is very poisonous, do not smell it.

(ii) Do not collect the gas in jars, prepare it side by side while performing the experiments.
Properties of Carbon-Monoxide:

Expt.: - 1. Take blue litmus solution in a test tube and pass the gas through it. There is no change in the colour of the solution. The gas is not acidic in character. Repeat the above experiment with the red litmus solution. There is again no change in the Litmus solution. The gas is not basic in character. It is neutral towards litmus solutions.


3. Pass the gas through lime water. It does not effect lime water.

4. It combines with oxygen to give carbon-dioxide:

\[
\text{Carbon-monoxide} + \text{Oxygen} \rightarrow \text{Carbondioxide}.
\]

5. It reduces heated metallic oxides to metals.

(i) Iron Oxide + Carbon-monoxide \rightarrow Iron + Carbon-dioxide

(ii) Lead Oxide + Carbon-monoxide \rightarrow Lead + Carbon-dioxide

UNIT-III

Knowledge:

Elements have been divided into metals and non-metals. Metals occur in nature in the free as well as combined state. Metals like gold, platinum, silver, mercury, copper, antimony,
arsenic and bismuth which are not much affected by air and water, are generally found in the free state (also known as native state). Most of the metals, occur in form of compounds, associated with sand and other earthy impurities.

General Physical Characteristics:

1. **State**: Metals exist in solid state at ordinary temperature.
2. **Lustre**: Metals possess a brilliant lustre when freshly cut. It is called metallic lustre.
3. **Hardness**: Most of the metals are hard.
4. **Specific Density**: Metals are generally heavy, with high density, varying from 0.53 to 22.5. Some of the metals having specific density less than five are known as light metals while others are heavy metals.
5. **Opaqueness**: Metals are opaque e.g. light cannot pass through them, metallic leaves are semi-opaque.
6. **Metals** have high melting and boiling points e.g. melting point of copper is 1083°C. Sodium and Potassium have low melting-points while mercury has low boiling point.
7. **Metals** are ductile. They are drawn in wires. They are malleable e.g. drawn into sheets.
8. **Metals** are very good conductors of heat and electricity.
9. **Solubility**: Metals do not dissolve except by a chemical reaction.
10. **Metals** when beaten produce sound.
General Physical Characteristics of Non-Metals:

1. **State**: With the exception of a few such as carbon, silicon, sulphur and phosphorus, which are solids, others are either gases or volatile liquids.

2. Do not possess metallic lustre.

3. Non-metals are not generally so hard. Diamond, the hardest substance known, is an exception.

4. Have low specific gravity which is in all cases less than five.

5. Non-metals have generally low melting points and boiling points.

6. They are not malleable and ductile.

7. They are poor conductors of heat and electricity.

8. They dissolve even without chemical action.


Comprehension:

Elements have been divided into metals and non-metals on the basis of difference of their physical and chemical properties. This classification is not satisfactory because there are many exceptions to most of the properties. Mercury is liquid at ordinary temperature. Iodine and graphite are non-metals which possess metallic lustre. Graphite and gas carbon is good conductors of heat and electricity. Some metals e.g. Sodium and Potassium are soft and can be cut with knife. Boron and Silicon are non-metals with high melting and boiling points.
Chemical Properties of Metals:

1. Metals react with oxygen to form basic oxides which react with acids forming salt and water, chromium and manganese form acidic oxides, besides basic oxides.

2. Reaction with acids: Some metals react with dil. acids, producing hydrogen.

   Zinc + Dil. Sulphuric Acid — Zinc Sulphate + Hydrogen
   Magnesium + Dil. Sulphuric Acid — Magnesium Sulphate + Hydrogen.

3. They form unstable hydride with difficulty.

4. Metals are electro-positive in nature.

Chemical Properties of Non-Metals:

1. Non-metals react with oxygen to form acidic oxides:

   (a) Sulphur + Oxygen ——— Sulphur-dioxide.
   (b) Carbon + Oxygen ——— Carbon-dioxide

   Both compounds are acidic in nature.

2. Generally do not react with dilute acids. They may dissolve but no gas is given off.

3. They are electro-negative but hydrogen is electropositive.


   Oxygen + Hydrogen ——— Water.

Mineral: Metal which occur in the form of compound, associated with sand and other earthly impurities, the whole mass being called mineral.
Ore: All the minerals are not suitable for the extraction of metal present in that. A mineral from which the metal can be profitably and conveniently extracted is called an ore.

Metalloids: They are the elements which show the properties of both metals and non-metals. There are many such properties which are shown by most of the metals and some non-metals. Arsenic and Antimony are typical metalloids. They behave as metals in their physical properties and as non-metals in their chemical properties. Arsenic is a good conductor of electricity, has a metallic appearance, and forms alloys. It also forms arsenious. Sulphide like copper, and mercury, on the other hand, it forms acidic oxides and forms salt, arsenites. Its hydride is stable and hydrolised.

Application:

Properties of Alloys: Properties of alloy depend upon the properties of their constituents. They are more hard but less malleable and ductile as compared to their constituents. They are mostly acid-proof and prevent corrosion.

Purposes of Alloy Formation:

(a) To increase hardness:— Hardness of iron increases when it is combined with Carbon. Manganese Steel (An alloy of Iron and ten percent Manganese) is very hard. Copper is mixed with gold to increase hardness of gold.
(b) To prevent corrosion: Stainless Steel (an alloy of Iron and chromium) is acid proof and not easily rusted. In Copper utensils eatables become poisonous but if they are kept in Bronze utensils, the eatables can be saved.

(c) To decrease the melting point, e.g., fusible alloys.

(d) To change colour e.g., Aluminium bronze (an alloy of Aluminium and Copper), to make the metals chemically less active e.g. sodium amalgam (an alloy of sodium and mercury) is less active than sodium.

Some Important Alloys and their Uses:

Brass (an alloy of copper and zinc) is used for making parts of machines, statues and weapons. Bronze (an alloy of Copper, Tin and Zinc) is white in colour and not easily spoiled. It is used for making utensils and statues. Stainless Steel (an alloy of Iron and Chromium) is acid proof and used for making parts of machines and utensils.

Aluminium Bronze (an alloy of Copper and Aluminium) is hard, non-corrosive, bright golden in colour and used for making utensils, ornaments and coins.

Solder is fusible alloy used for welding purposes.
### Process Skills

<table>
<thead>
<tr>
<th>Physical Property</th>
<th>Learning activities</th>
<th>Observations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>State</strong></td>
<td>Observe the physical state of given metals and non-metals.</td>
<td>Out of given metals: Copper, Iron, Zinc, Silver, Nickle are solids. Mercury is liquid.</td>
</tr>
<tr>
<td><strong>Lustre</strong></td>
<td>Observe freshly cut Iron ring, Copper wires, Sulphur, Phosphorous and graphite.</td>
<td>Given metals have metallic lustre. Out of given non-metals Sulphur, Phosphorous have no lustre. Graphite has metallic lustre.</td>
</tr>
<tr>
<td><strong>Hardness</strong></td>
<td>Cut metals (Iron wire, Copper Sheet), Sodium with knife, Make powder of given sulphur pieces and charcoal.</td>
<td>Iron wire and copper sheet are hard and cannot cut with knife. Sodium is soft and is cut to pieces. Sulphur and charcoal are soft and are easily powdered.</td>
</tr>
<tr>
<td><strong>Melting &amp; boiling points</strong></td>
<td>Heat small amount of Sulphur in test tube. Also heat small pieces of Iron.</td>
<td>Sulphur melts on heating and on strong heating is converted into vapours. Iron does not melt.</td>
</tr>
<tr>
<td><strong>Malleability and ductility</strong></td>
<td>Observe Copper wires, Iron sheets, Sulphur and Coal.</td>
<td>Copper and Iron are malleable and ductile. They can be drawn into wires and sheets. Sulphur and coal cannot be drawn into wires and sheets.</td>
</tr>
<tr>
<td><strong>Conductivity</strong></td>
<td>Heat a piece of charcoal from one side. Take Iron wire and heat its one end observe the working of Iron press.</td>
<td>One end of the charcoal piece is red hot but the other remains cold. Charcoal does not conduct heat. It is a bad conductor of heat. When Iron wire is heated, heat passes from one end to the other end. Iron press gets heated. It is because Iron conducts heat and electricity.</td>
</tr>
<tr>
<td><strong>Sound</strong></td>
<td>Throw Iron plate from the table, on the floor. Also throw piece of charcoals and sulphur.</td>
<td>When Iron plate falls on floor, sound is produced. Non-metals e.g., charcoal and Sulphur do not produce sound.</td>
</tr>
</tbody>
</table>

**Note:** For diagrams, please see the Appendix I.