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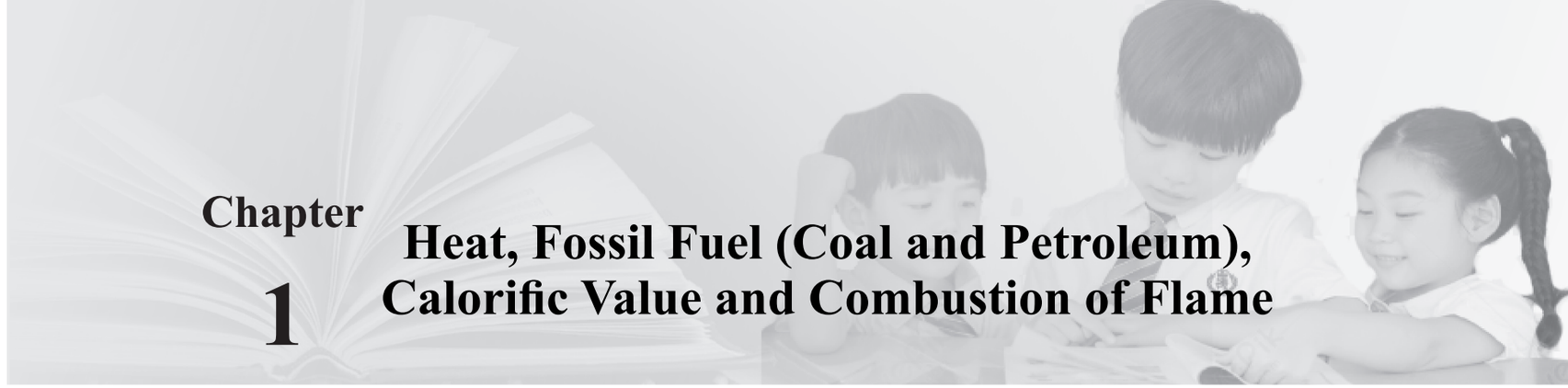


Chapter 1 Heat, Fossil Fuel (Coal and Petroleum), Calorific Value and Combustion of Flame

I. Heat and Temperature

We experience cold and heat every day. Having less or more heat causes us to feel cold and heat. When heat flows out of our body we feel cold. If the heat flows into our body from the outer environment then we feel hot.

- Heat is a type of energy that is related to the motion of the molecules of a substance.
- The degree of hotness or coldness is called temperature.

The higher the temperature of the substance, the faster the movement of its molecules, thus, more energy exists in the form of heat. Heat always flows from a body at a higher temperature to a body temperature, therefore, during the summer when the temperature of the environment is more than our body, we feel hot, and in the winter the temperature outside is less than the temperature of the body, hence we feel cold.

The direction of heat flow between two objects depends on their temperature.

II. Effect of Heat as an Energy

Heat is a form of energy that is associated with the motion of the molecule of a substance.

Application of Heat in Daily Life :

- Steam is formed due to heat.
- Clothes dry up in the sun due to the heat.
- Salt is obtained from seawater with the help of heat.

III. Conversion Of different Energies into Heat

There are many other types of energies transformed into heat.

- Burning candles causes chemical energy to change into heat.
- The electric energy in the electric furnace is converted into heat.
- In an electric heater electric energy is also changed into heat.

IV. Effects of Heat

The higher the speed of the molecules of a substance, the higher its temperature and by providing heat the speed of its molecules increases. When any object is heated, one or more of the following effects may appear.

(i) Change in size - Metals like iron, mercury etc. expand on heating.

(ii) Rise in temperature - When a body is heated, it becomes hot.

(iii) Change of state - Solid substances change to liquid and gases. Water in a liquid state changes to a solid, liquid and gaseous state. For example, liquid water from ice and steam from water. The heat used to convert ice into water is called the latent heat of fusion.

(iv) Change in physical and chemical properties of a substance - Iron when heated, becomes red hot.

(v) Damage to living cells etc. - If the leaf is lying in the sun, then it becomes dry. If the person remains in the sun for a long time, then the colour becomes black.

V. Measurement of Temperature

The measurement of the hotness or coldness of a body is known as its temperature.

To find out how hot or cold an object is we use a special device known as a thermometer.

Thermometer (Clinical Thermometer)

- The thermometer that measures our body temperature is called a clinical thermometer. A clinical thermometer consists of a long, narrow, uniform glass tube. It has a bulb at one end. This bulb contains mercury.
- Outside the bulb, a small shining thread of mercury can be seen. You can see a kink near the bulb.
- This kink prevents mercury levels from falling on its own when the thermometer is taken out of the mouth and we can read the thermometer easily.
- You will also find a scale on the thermometer. The scale we use is the Celsius scale, indicated by °C. A clinical thermometer reads temperature from 35°C to 42°C only.

In a thermometer, another scale is also used to measure temperature which is known as the Fahrenheit scale (°F). On the Fahrenheit scale thermometer reads from 94°F to 108°F only.

The normal temperature of a healthy person is 37°C or 98.6°F.

VI. Laboratory Thermometer

To measure the temperature of other objects, there are other thermometers. One such thermometer is known as the laboratory thermometer.

A Laboratory thermometer consists of a long, narrow glass tube. The lower end of this tube is like a bulb. This tube contains mercury or alcohol. Its upper end is sealed. The glass tube is kept in ice cubes. The point in the tube where mercury becomes steady after getting cooled is marked as 0°C.

Now the tube is kept in the steam of boiling water. The mercury starts to expand inside the tube. The point in the tube where mercury becomes steady is marked as 100 °C. The intervening space between the two points is divided into

100 equal parts. Thus, the measure of each small division is 1°C. Generally, the range of this thermometer is -10°C to 110°C.

VII. Propagation of Heat

The process of transfer or displacement of heat is called propagation of heat.

Conduction : The heat reaches the end of less temperature from the end of the higher temperature, and after some time the other end of the metal becomes hot. This method of heat transfer is called **conduction**.

Convection : The materials which allow heat to pass through them easily are conductors of heat. For example, aluminium, iron and copper. The materials which do not allow heat to pass through them easily are poor conductors or insulators of heat such as plastic and wood.

When water is heated, the water near the flame gets shot. Hot water rises. The cold water from the sides comes in to take its place. This water also gets hot and rises and water from the sides moves down. This process continues till the whole water gets heated. This mode of heat transfer is known as convection.

The air near the heat source gets hot and rises. The air from the sides comes in to take its place. In this way, the air gets heated. This air also gets hot. Thus, the process continues to take place.

Applications of convection in daily life :

1. Chimney: Smoke and hot gases from homes and factories rise due to convection and get out through the chimney.
2. Ventilators

Radiation : There is no medium such as air in most parts of the space between the earth and the sun, hence, from the sun the heat comes to us through another process known as **radiation.** The transfer of heat by radiation does not require any medium. When we sit in front of a room heater, we get heat from this process.

Our body too gives heat to the surroundings and receives heat from it through radiation.

A hot utensil kept away from the flame cools down as it transfers heat to the surroundings by radiation. It means that all hot bodies radiate heat. When this heat falls on some object, a part of it is absorbed and a part is reflected.

1. Resources and its Types

We use various materials for our basic needs. Some of them are found in nature and some have been made by human efforts. These have been classified as under :

I. Natural Resources

The resources which are obtained from nature are called natural resources. These are of two types :

(i) Inexhaustible Natural Resources

These resources are present in unlimited quantities in nature and are not likely to be exhausted by human activities. Examples : Sunlight, air, etc.

(ii) Exhaustible Natural Resources

The amount of these resources in nature is limited and thus these can be exhausted by excessive human usage. Examples : Forests, coal, petroleum, minerals, wild life, natural gas, etc.

II. Man-Made Resources

- When a natural resource undergoes drastic change by human intervention, it becomes human-made resource. For example; iron ore is processed to make steel and hence steel is a man-made resource, Buildings, bridges, railways, machines, etc. are examples of human-made resources. Technology is also a human-made resource.
- Exhaustible natural resources like coal, petroleum and natural gas were formed from the dead remains of living organisms (fossils), therefore, they are called **fossil fuels**. Wood is not a fossil fuel.
- The study of fossils is called paleontology.

2. Coal

- Coal is a complex mixture of free carbon and compounds of carbon containing hydrogen, oxygen, nitrogen and sulphur.
- It is believed that millions of years ago, the forests got buried under the surface of earth and had no contact with oxygen. They slowly started to decompose and formed dense sponge like material called peat. Over millions of years, due to tremendous pressure and heat, finally these got transformed into coal.
- As coal mainly contains carbon, the slow process of conversion of dead vegetation into coal is called **carbonization**. Upon heating in air, coal burns and produces mainly carbon dioxide. Diamond is an allotrope of carbon.
- Coal is used as a fuel in large furnaces and industries, production of bricks, thermal power stations, making food and other domestic purposes. For obtaining coal large and deep mines are made in the earth's crust. Pure coal is obtained from relatively deep and dangerous mines.
- Charcoal is produced from the wood of trees. Like coal it also has the capability of radiating energy continuously.
- Coal is classified into five main categories based on the amount of carbon it contains and the heat energy it can produce :

(i) Peat : It is the first stage of coal and contains 10-15% of carbon. It is the poorest variety of coal.

(ii) **Lignite :** The carbon content is 25-35%.

(iii) **Subbituminous coal :** It contains 35-44% carbon

(iv) **Bituminous coal :** It contains 45-86% carbon. It is common household fuel and industrial fuel.

(v) **Anthracite coal :** It contains 86-97% carbon

- **Destructive/Fractional Distillation of Coal :** The process of heating coal in the absence of air is called the destructive distillation of coal. When coal is heated in the absence of air, a number of products are obtained such as Coke, Coal tar and Coal gas. On destructive distillation, 1000 kg of coal gives 700kg of coke, 100 liters of ammonia, 50 litres of coal tar and 400 m^3 of coal gas.

(i) **Coke :** It contains 98 % carbon. It is porous and the purest form of coal. It is a good fuel and burns without smoke. It is largely used as a reducing agent in the extraction of metals from their ores. It is also used in making fuel gases like water gas and producer gas.

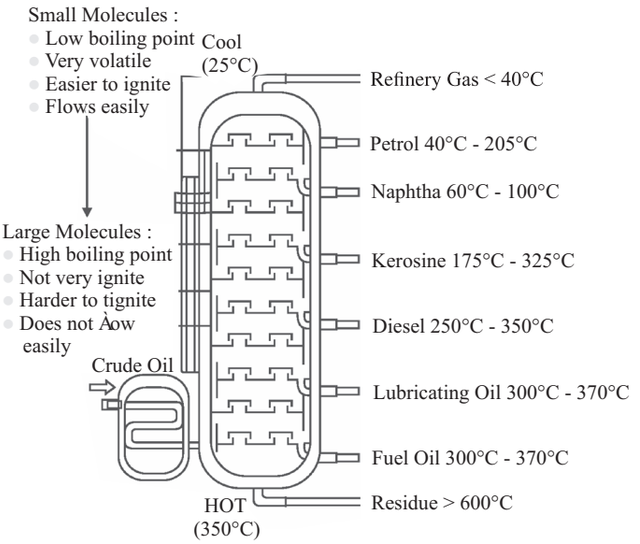
(ii) **Coal Tar (Liquid) :** It is a mixture of different carbon compounds. Its fractional distillation gives many chemical substances (Benzene, Toluene, Phenol and Aniline) which are further used in the preparation of dyes, explosives, paints, synthetics fibers, drugs, photographic materials, roofing materials and pesticides.
Naphthalene balls (also obtained from coal tar) are used to repel moths and other insects.Initially coal tar was used in metalling the roads but these days bitumen, a petroleum product is used. **Bitumen** is a sticky, black, highly viscous liquid or semi-solid form of petroleum.

(iii) **Coal Gas :** Coal gas is mainly a mixture of hydrogen, methane and carbon monoxide. It is obtained during the processing of coal to get coke. It is an excellent fuel. It was earlier used for lighting houses, factories and streets in Mumbai until 1950. Now it is mainly used as a source of heat.

(iv) **Liquid Ammonia :** It is used to make fertilizers.

3. Petroleum

- It is dark brownish to green coloured viscous liquid. It is also a fossil fuel. It has a strong foul smell due to the presence of sulphur containing compounds in it. It is generally referred to as crude oil and black gold.
- Its name is derived from Latin words Petra (meaning rock) and Oleum (meaning oil). Thus, petroleum literally means "Rock Oil". Petroleum is a complex mixture of solid, liquid and hydrocarbons, mixed with salt water and earthy particles. It is always found trapped between two impervious rocks.
- Iran, Iraq, Kuwait and other Arab countries are the major petroleum-producing countries in the world.
- **Formation of Petroleum :** It is believed that petroleum is formed by the anaerobic (in the absence of oxygen) decomposition of extremely small sea animals and plants which got buried in the sea bed millions of years ago.
- **Occurrence of Petroleum :** Petroleum occurs at a moderate depth (500 m to 200 m) between the 2 layers of impervious rocks. The petroleum is lighter than water and thus it can float over it. Above petroleum, natural gas is found and it is found trapped between the rock cap and petroleum layer.
- **The Drilling of Oil Wells to get Petroleum :** To get petroleum, a hole is drilled in the Earth's crust & when it reaches the rock cap, the natural gas comes out first with a great pressure. When the pressure of gas subsides, petroleum starts flowing out due to the pressure of natural gas.
- **Refining of Petroleum :** Petroleum being a mixture of several hydrocarbons cannot be used in natural form. Before being put to use, it has to be purified or refined. The process of separating the various components of petroleum from one another is known as the refining of petroleum and is carried out in petroleum refineries. This is done by a process called "Fractional Distillation" in which, on heating the crude oil, its different components get separated on their respective boiling points.



- **Uses of Petroleum :** Many useful substances are obtained from petroleum and natural gas. These are termed as 'Petrochemicals'. These are used in the manufacture of detergents, fibres (polyester, nylon, acrylic etc.), polythene and other man-made plastics.
- **Below are the various constituents of petroleum and their uses**

S. No.	Constituents of petroleum	Uses
1.	Petroleum Gas in Liquid form (LPG)	Fuel for home and industry

2.	Petrol	Motor fuel, aviation fuel, solvent for dry cleaning.
3.	Kerosene	Fuel for stoves, lamps and for jet aircrafts.
4.	Diesel	Fuel for heavy motor vehicles, electric generators.
5.	Lubricating oil	Lubrication
6.	Paraffin wax	Ointments, candles, vaseline etc.
7.	Bitumen	Paints, road surfacing.

Do you know?

- ⋆ The world's first petroleum well was drilled in Pennsylvania, USA in 1859.
- ⋆ In 1867, oil was stuck at Makum in Assam. In India, oil is found in Assam, Gujarat, Mumbai High and in the river basins of Godavari and Krishna.

4. Natural Gas

- Natural gas was formed millions of years ago along with petroleum when small sea plants & animals died & got buried under the earth. Further due to anaerobic conditions these got changed to gas.
- It also occurs in coal mines and petroleum wells. It mainly contains 90% methane.
- **Composition of Natural Gas :** It consists mainly of methane (about 85%), ethane (about 10%) propane (about 3%) and butane. The way of using natural gas is in form of CNG (Compressed Natural Gas) or LNG (Liquified Natural Gas).
- **CNG :** When natural gas is compressed at high pressure then it is called CNG. CNG is used for power generation and nowadays auto, buses and cars run on it, because it is less polluting. The great advantage of CNG is that it can be supplied through pipes and hence used in burning in homes and industries. Such a network of pipelines exists in Vadodara (Gujarat), some parts of Delhi and other places.
- **Occurrence :** It is generally found trapped between impervious rocks, sometimes along with petroleum & sometimes without petroleum. In our country, Tripura, Rajasthan, Maharashtra and in the Krishna Godavari Delta are the reserves of natural gas.
- **Liquefied Petroleum Gas (LPG) :** It is an important product of natural gas. LPG is the abbreviation or short form for liquefied petroleum gas. Main components of LPG are propane, butane and small quantities of methane. Like all fossil fuels, it is a non-renewable source of energy.

  It is extracted from crude oil and natural gas. Normally, the gas is stored in liquid form under pressure in a steel container, cylinder or tank. LPG is highly inflammable and must therefore be stored away from sources of ignition and in a well-ventilated area, so that any leak can disperse safely. It is used for standard heating and cooking purposes. Hydrogen gas obtained from natural gas, is used in the production of fertilisers (urea). Propane and butane are the two major components of LPG in the ratio 40:60.

Do you know?

- ⋆ Burning of fuels causes air pollution which leads to global warming. So we need to use fuels only when it is necessary. In India, the Petroleum Conservation Research Association (PCRA) advises people how to save petrol/diesel while driving.
- ⋆ Sunlight is a renewable natural resource.

5. Alternative Sources of Energy

- **Biodiesel :** It is a fuel obtained from vegetable oils such as Soyabean oil, Jatropha oil, Cornoil, Sunflower Oil, Cotton seed oil, Rice bran oil and Rubber seed oil.
- **Wind Mills :** When wind blows, they rotate and current is produced in the dynamo.
- **Solar Energy :** Sun is the foremost energy source that makes life possible on our earth.Solar energy is harnessed using (i) solar cookers (ii) solar water heaters (iii) solar cells.
- **Gobar Gas :** It is obtained by the fermentation of cow dung in the absence of air (anaerobic conditions). It mainly contains methane and a little ethane. It is widely used in rural areas for cooking and operating engines.

Do you know?

- ⋆ Hydrogen could be the best alternative fuel. It is a clean fuel as it gives out only water while burning. Moreover, it has the highest energy content. It does not pollute the air.
- ⋆ Sewage sludge can be decomposed by microorganisms to produce methane gas along with impurities like carbon dioxide and hydrogen sulphide. After removing these impurities, methane gas can be used as an efficient fuel.
- ⋆ Sails in boats and ships are used to harness wind energy.

6. Combustion

- A chemical process in which a substance reacts with oxygen to give off heat is called **combustion**.
- The substances such as paper and fuel etc., which undergo combustion are known as **combustible substances**. Sometimes, heat is accompanied by light, either as a flame or as a glow, during combustion.
- Combustion is a chemical process. Some materials burn with flame like a candle while some materials burn without flame-like coal.
- A combustion reaction may be written as :

  (i) Charcoal burns in air to give carbon dioxide and heat.

$$C + O_2 \rightarrow CO_2 + \text{Heat}$$

(ii) Methane burns in air forming carbon dioxide, water and heat.

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + \text{Heat}$$

- It is important to note that different substances burn at different temperatures. For a substance to burn, some minimum temperature is required and this minimum temperature is known as **"Ignition Temperature"**. For example, the Ignition temperature of phosphorus is 35°C. So, unless phosphorus is heated to 35°C, it will not catch fire.
- Substances which have very low ignition temperature or can easily catch fire are called **Inflammable Substances.** eg. Petrol, Alcohol, LPG, etc.
- **Necessary conditions for combustion :**
  1. The heat-ignition temperature must be within access.
  2. Fuel- Fuel should be combustible.
  3. Oxygen- a suitable amount of oxygen must be available there.
- **Ignition Temperature of Different Materials**

Material	Ignition Temperature
White Phosphorus	35 degree Celsius
Petrol	246 degree Celsius
Kerosene	220 degree Celsius
Diesel	210 degree Celsius
Wood	300 degree Celsius
Coal	454 degree Celsius
Piece of paper	233 degree Celsius
Alcohol	365 degree Celsius

Do you know?

★ In the sun, heat and light are produced by nuclear reactions.

- Nuclear fusion takes place inside the sun's nucleus, where hydrozen nuclei (protons) combine to form helium nuclei. Protons - This process, known as the proton chain, involves a series of nuclear reactions that release vast amounts of energy in the form of light and heat.
- Combustion is an oxidation process.
- **Controlling Fire :** There are 3 conditions necessary for producing and sustaining combustion.

  (i) Presence of a combustible substance (Fuel)
  (ii) Presence of a supporter of combustion. (Air for oxygen)
  (iii) Attainment of ignition or kindling temperature.(Heat)

  Thus, fire can be controlled by removing one or more of these requirements for producing and sustaining combustion. The fire extinguisher also tries to cut off the supply of air or bring down the temperature of the fuel or both, to control the fire.

Fire Fighting

News of fire breaking out in homes, shops and factories due to carelessness and faulty equipment is common. But what is more important is to timely control it.

Combustion or Fire sustain due to the presence of all the necessary conditions of Fire. So, it can be controlled by removing one or more of these.

It is quite difficult to remove fuel from the site of the fire, So, the fire is extinguished by the following two factors.

1. By cutting off the supply of air: The supply of air can be stopped by covering the burning solid fuel with soil, sand and a blanket.
2. By cooling the combustible material below its ignition temperature: Water is the most common fire extinguisher. Water cools the combustible material below its ignition temperature. This prevents the fire from spreading. Water vapours also surround the combustible material, helping in cutting off the supply of air. But water works only when things like wood and paper are on fire.

If electrical equipment is on fire, water may conduct electricity and harm those trying to douse the fire.

Water is also not suitable for fires involving oil and petrol. Water is heavier than oil. So, it sinks below the oil, and the oil keeps burning on top.

For fires involving electrical equipment and inflammable materials like petrol, carbon dioxide is the best extinguisher. Carbon dioxide covers the fire like a blanket. Since the contact between the fuel and oxygen is cut off, the fire is controlled.

- **Fire Extinguishers :** For fires involving electrical equipment and inflammable materials like petrol, carbon dioxide (CO_2) is the best fire extinguisher and not water. CO_2, being heavier than oxygen, covers the fire like a blanket, hence cutting off the contact of fuel with oxygen and bringing down the temperature.

  Dry powder of chemicals like sodium bicarbonate (baking soda) or potassium bicarbonate release CO_2 near fire. Hence, are another good source to extinguish fire.
- CO_2 extinguishers are the type of extinguishers that can withstand up to 1000 volts.
- Fire extinguishers contain chemicals such as sulphuric acid H_2SO_4 and sodium bicarbonate $NaHCO_3$
- When a fire extinguisher is turned on, sulfuric acid reacts with sodium bicarbonate to produce corbon dioxide (CO_2) gas.

Do you know?

History of Matchsticks

★ More than five thousand years ago small pieces of pinewood dipped in sulphur were used as matches in ancient Egypt. A mixture of antimony trisulphide, potassium chlorate and white phosphorus with some glue and starch was applied on the head of a match made of suitable wood. When struck against a rough surface, white phosphorus got ignited due to the heat of friction. This started the combustion of the match. However, white phosphorus proved to be dangerous

both for the workers involved in the manufacturing of matches and for the users.

- ⋆ These days the head of the safety match contains only antimony trisulphide and potassium chlorate. The rubbing surface has powdered glass and a little red phosphorus (which is much less dangerous).When the match is struck against the rubbing surface, some red phosphorus gets converted into white phosphorus. This immediately reacts with potassium chlorate in the matchstick head to produce enough heat to ignite antimony trisulphide and start the combustion.
- ⋆ Limestone is mainly composed of calcium carbonate ($CaCO_3$)] which is a chemical compound. when limestone undergoes a chemical reaction such as combustion or decomposition, it releases energy in the form of heat. This energy is stored within the chemical bonds of limestore and when these bonds are broken, the energy is released in the form of chemical energy. therefore, the energy released form limestore is classified as chemical energy.
- ⋆ Solid carbon dioxide is called dry ice.

- **Types of Combustion :** Combustion is mainly of three types–
  - **(i) Rapid combustion :** The combustion in which the gas burns rapidly and produces heat and light is called rapid combustion.
    For example : When a burning matchstick is brought near a gas burner and the gas tap is opened, the gas immediately starts burning with the production of heat and light. Magnesium ribbon burns to form magnesium oxide and produces heat and light
  - **(ii) Spontaneous combustion :** The combustion in which no external heat is given is known as spontaneous combustion. For example: Forest fires are the result of spontaneous combustion due to heat of sun or lightning strike. Burning of white phosphorus in air at room temperature.
  - **(iii) Explosion :** The combustion in which large amount of gases are evolved with the production of a tremendous amount of heat, light and sound is called explosion. For example : When a cracker is ignited, a sudden reaction, takes place-in which at high speed large amount of gas is evolved with the production of tremendous amount of heat, light and sound.
- **Difference between Rapid and Spontaneous Combustion**

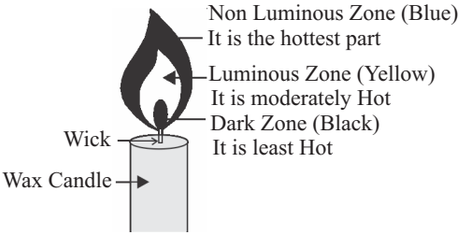
Rapid combustion	Spontaneous combustion
It is to be initiated once	It takes place by itself.
External heat is required	No external heat is required to start it
Large amount of heat is	Small amount of heat and light
evolved in a short time	is evolved

Rapid combustion	Spontaneous combustion
Example : Burning of	Burning of white phosphorous
domestic cooking gas	on its own when kept in air for
exposed in a gas burner	some time

7. Flame

- A region of burning gases is called flame. A substance will burn with a flame, only if some gaseous substance is there to burn.
- The substances which vapourise during burning, give flames. For example, kerosene oil and molten wax rise through the wick and are vapourised during burning and form flames. Charcoal, on the other hand, does not vapourise and so does not produce a flame.
- **Structure of a flame :** In order to understand the structure of a flame, light a wax candle and watch its flame. There are different coloured zones in the flame. Starting from the base of the flame, a flame has **three zones**.

Structure of Candle Flame

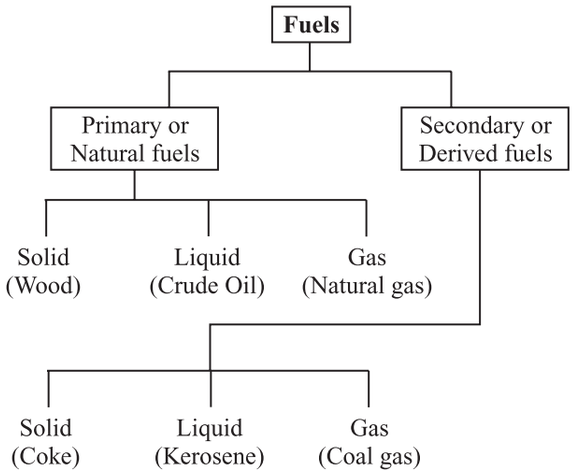


- **(i) Outermost non-luminous zone of complete combustion (Blue)**
  This zone is poorly visible and is slightly blue. It is the hottest part of the flame where complete oxidation (burning) of the fuel is taking place. Goldsmiths blow the outermost zone of a flame with a metallic blow-pipe for melting gold and silver.
- **(ii) Luminous zone of partial combustion (Yellow)**
  In this region of the flame, hydrogen burns with a brilliant **yellow luminous flame**. Burning hydrogen combines with oxygen to form water vapour. Carbon also burns in this zone giving some luminosity to the flame and producing carbon dioxide. Some unburnt carbon particles are left which give rise to soot.
- **(iii) Dark innermost zone of unburnt wax vapours (Black)** Surrounding the wick is the dark zone. There is no burning in this zone. If we pass a wooden splinter through the dark zone of the flame, it comes out unscratched (unburnt) showing that there is no 'burning' in this zone. However, some burnt wax vapours are present in this zone.

8. Fuel

- Any substance which is easily available and burns in air at a moderate rate, producing a large amount of heat energy, without leaving behind any undesirable residue is called **fuel**. For *e.g.,* Wood, charcoal, petrol, kerosene, etc.

- If a fuel is present in its natural state then it is known as a natural fuel, while a fuel is known as a derived fuel if it is processed to improve its quality. It can be classified into natural (primary) fuels and derived (secondary) fuels.



- **Characteristics of a Good Fuel**
  - (i) It should be cheap and readily available.
  - (ii) It should be easy to store.
  - (iii) It should burn at a slow rate and its rate of combustion should be controllable
  - (iv) It should have low ignition temperature. Substances which have low ingition temperature burn easily.
  - (v) It should produce a very small amount of residues such as ash.
  - (vi) It should have large calorific value.
  - (vii) It should not produce gases which pollute the air.
  - (viii) It should not produce any hazards during transportation.
- **Classification of fuels :** On the basis of physical state, fuels are classified into three types :
  - **(i) Solid fuels :** The fuels which occur in a solid state at room temperature are called solid fuels. Example : Wood, agricultural residues, charcoal, coal, coke, etc.

Do you know?
★ Uranium is used as fuil in nuclear reaction.

  - **(ii) Liquid fuels :** The fuels which occur in a liquid state at room temperature are called liquid fuels. Example : Liquefied hydrogen, petrol, oil, kerosene, diesel, etc.
  - **(iii) Gaseous fuels :** The fuels which occur in a gaseous state at room temperature are called gaseous fuels. Example : Water gas, producer gas, coal gas, compressed natural gas (CNG) and gobar gas, etc.
- **Fuel efficiency :** Any fuel contains carbon as its main constituent. During the combustion of fuel carbon combines with oxygen and liberates large amounts of heat. It is expected that a fuel liberates maximum amount of heat in a short time. The efficiency of a fuel can be understood from the following terms :
  - **(i) Specific Energy :** Specific energy is the amount of energy produced by the **unit mass of a fuel**. It is defined as the **energy per unit mass**. It is used to measure the stored energy in certain substances. Its unit is **J/kg**.
  - **(ii) Calorific Value :** It is the quantity of heat produced by the complete combustion of 1 kg of fuel at constant pressure and normal conditions. In case of liquid or gaseous fuels to measure the calorific value, their volumes are taken into consideration while for solid fuels their masses are taken into account. It is measured in **Kilo Joule per Kilogram (kJ/Kg)**. **The more the calorific value of a fuel, the more is the efficiency of the fuel**.

$$\text{Calorific Value} = \frac{\text{Amount of heat liberated}}{\text{Total mass or volume of fuel}}$$

Examples for understanding Calorific Value :

Example 1.
In an experiment 4.5 kg of a fuel was completely burnt. The heat produced was measured to be 180,000 kJ. Calculate the calorific value of the fuel.
Solution :
Given : Weight of fuel burnt = 4.5 kg
To find : Calorific value = ?
Formula used :

$$\text{Calorific value} = \frac{\text{Amount of heat produced}}{\text{Weight of fuel burnt}}$$

$$\text{Calorific value} = \frac{180000}{4.5}$$

$\therefore$ Calorific value = 40,000 kJ/kg.

- Calorific value of some fuels is given in the following table :

Fuel	Calorific Value (KJ/kg)
Cow dung cake	6000 – 8000
Wood	17000 – 22000
Coal	25000 – 33000
Petrol	45000
Kerosene	45000
Diesel	45000
Methane	50000
CNG	50000
LPG	550000
Biogas	35000 – 40000
Hydrogen	150000

- **Ideal Fuel :** An ideal fuel is one which :
  - (i) Has high calorific value.
  - (ii) Do not cause any pollution or produce harmful gases on combustion.
  - (iii) Is easily available at low cost.

(iv) Is easy to handle, store and transport.

(v) Has moderate ignition temperature.

(vi) Has moderate rate of combustion.

- **Harmful effects of burning fuels :** The increasing fuel consumption has harmful effects on the environment. The main products formed during the fuel combustion which produce harmful effect are :

(i) **Carbon fuels** like wood, coal, petroleum release unburnt carbon particles. These fine particles are dangerous pollutants causing respiratory disease, such as asthma.

(ii) **Incomplete combustion** forms carbon monoxide gas. It is a very poisonous gas. It is dangerous to burn coal in a closed room. The carbon monoxide gas produced can kill persons sleeping in that room.

(iii) Combustion of most fuels releases carbon dioxide in the environment. Increased percentage of carbon dioxide in the air causes **global warming**. Global warming is the rise in temperature of the earth. This results in melting of polar glaciers which leads to rise in sea level and floods in the sea coast.

(iv) Burning of coal and diesel releases sulphur dioxide gas. It is an extremely suffocating and corrosive gas. Sulphur dioxide and nitrogen oxide dissolve in rain water to form acid. Such rain is called **acid rain**. It is very harmful for crops, buildings and soil.

(v) Wood is also used as a fuel. Burning of wood gives a lot of smoke which causes **air pollution** and is also very harmful for humans. It may lead to many respiratory problems. Cutting of trees for obtaining wood leads to deforestation which is quite harmful to the environment. Therefore, wood is replaced by coal or other fuels such as LPG.

(vi) Carbon particles of smoke or ash get suspended in the air. Excessive amounts of them in the air causes **breathing problems**.

Important Questions

1. In Fire extinguishers, a concentrated acid is used to form carbondioxide. Name the acid which participated in that reaction :
(A) conc. H_2SO_4
(B) Conc. HCl
(C) conc. HNO_3
(D) All of these

2. Which one is the main source of energy?
(A) Wind (B) Petrol
(C) Coal (D) Sun

3. Which type of energy is released from limestone?
(A) Chemical energy
(B) Potential energy
(C) Kinetic energy
(D) Mechanical energy

4. For Combustion air required
(A) Oxygen
(B) Nitrogen
(C) Chlorine
(D) Carbon-dioxide

5. Combustion is a process
(A) Oxidation
(B) Reduction
(C) Decomposition
(D) Combination

6. Renewable source of Energy is :
(A) Petrol (B) Diesel
(C) Coal (D) Wind

7. Which of the following is having highest calorific value of a fuel ?
(A) Wood
(B) Petrol
(C) L.P.G.
(D) Hydrogen

8. Which fuel is used in Nuclear reactions ?
(A) Oxygen
(B) Uranium
(C) Calcium
(D) Iron

9. The Calorific value of "CNG" fuel is :
(A) 45,000 KJ/Kg
(B) 35,000 KJ/Kg
(C) 50,000 KJ/Kg
(D) 55,000 KJ/Kg

10. The gas used in homes is :
(A) L.P.G. (B) C.N.G.
(C) CO_2 (D) O_2

11. Which of the following products is not obtained from the refining of petroleum?
(A) Diesel
(B) lubricating oil
(C) Petroleum gas
(D) Natural gas

12. The least polluting fuel is :
(A) Wood
(B) Hydrogen
(C) Methane
(D) Butane

13. Which of the following does not produce CO_2 ?
(A) Wind Energy
(B) Hydroelectric
(C) Geothermal Energy
(D) Solar Energy

14. The substance which have very low ignition temperature?
(A) Burns easily
(B) Burns very slowly
(C) Both A and B
(D) None

Answer key

1. (A) **2.** (D) **3.** (A) **4.** (A) **5.** (A)
6. (D) **7.** (D) **8.** (B) **9.** (C) **10.** (A)
11. (D) **12.** (B) **13.** (A) **14.** (D)

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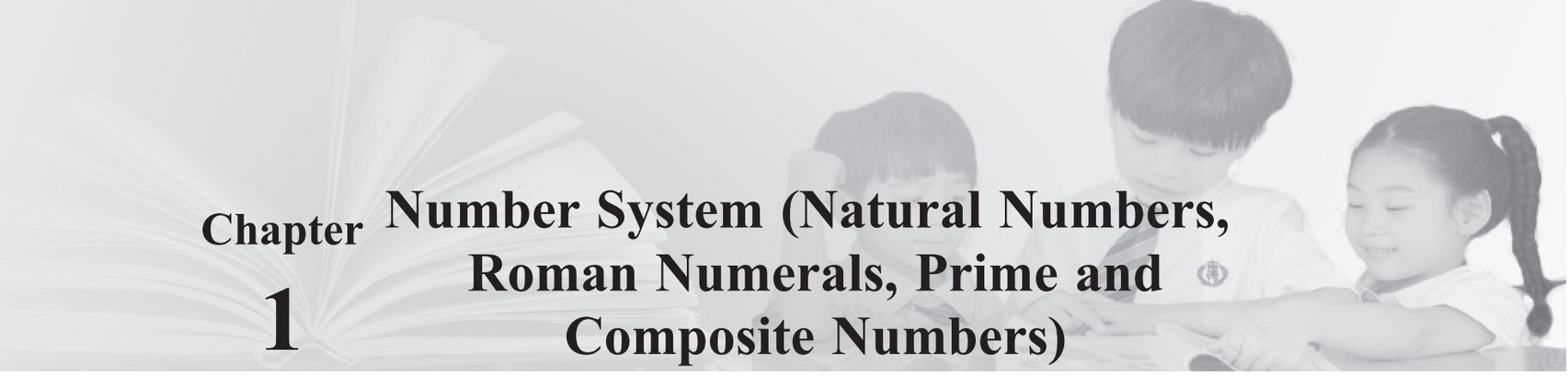


Chapter 1 Number System (Natural Numbers, Roman Numerals, Prime and Composite Numbers)

1. IMPORTANT TERMINOLOGY

1.1 Digits : 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9 are defined as digits in Mathematics. We can create many numbers by using these digits. For example : 10, 123, 456, 789 etc.

1.2 Number System : There are mainly two types defined in the number system. These are :

I. Decimal Number System : It contains 0 to 9 digits. That's why it is called *decimal number system*. In this system, the numbers is read and written in two ways : Indian number system and International number system.

In the Indian number system or Hindi-Arabic system, the numbers are read and written as per their place values. These numbers are read as per the following table.

Periods	Crores		Lakhs		Thousands		Ones		
Value	10,00,00,000 (Ten Crores)	1,00,00,000 (Crore)	10,00,000 (Ten Lakhs)	1,00,000 (Lakh)	10,000 (Ten Thousands)	1,000 (Thousand)	100 (Hundred)	10 (Ten)	1 (One)
	10^8	10^7	10^6	10^5	10^4	10^3	10^2	10^1	10^0

Example : Number 51,45,42,786 can be read as Fifty-one Crores Forty-five Lakhs Forty-two Thousands Seven Hundred and Eighty-six. It is also called number name.

Unit Conversions :

- 1 tens = 10 units
- 1 Hundred = 10 tens = 100 units
- 1 Thousand = 10 Hundreds = 100 tens = 1000 units
- 1 Lakh = 10 Thousands = 100 Hundreds = 1000 tens
- 1 Crore = 10 Lakhs = 100 Thousands = 1000 Hundreds

In International number system, the numbers are read and written as per the following table.

Periods	Millions			Thousands			Ones		
Value	100,000,000 (Hundred Millions)	10,000,000 (Ten Millions)	10,00,000 (Millions)	100,000 (Hundred Thousand)	10,000 (Ten Thousand)	1,000 (Thousand)	100 (Hundred)	10 (Ten)	1 (One)
	10^8	10^7	10^6	10^5	10^4	10^3	10^2	10^1	10^0

Example : Number 14,542,786 can be read as Fourteen Millions Five Hundred Forty-two Thousand Seven Hundred Eighty-six.

II. Roman Number System : In this system, numbers are represented by Latin alphabets. The Roman numerals used in, are based on seven symbols or letters.

Roman System	I	V	X	L	C	D	M
Hindu Arabic System	1	5	10	50	100	500	1000

Example : 25 can be written as XXV and 101 as CI.

Note

- A letter repeats its value many times (XXX = 30, CC = 200, etc.). A letter can only be repeated three times.
- If one or more letters are placed after another letter of greater value, add that amount.

  For example,

  VII = 7 (5 + 1 + 1); LXI = 61 (50 + 10 + 1); MCC = 1200 (1000 + 100 + 100)
- If a letter is placed before another letter of greater value, subtract that amount.

  For example,

  IV = 4 (5 – 1); XIV = 14 (10 + 5 – 1); CM = 900 (1000 – 100)
- Only subtract powers of ten (I, X, or C, but not V or L).
- Only subtract one number from another.
- Do not subtract a number from one that is more than 10 times greater (that is, you can subtract 1 from 10 [IX] but not 1 from 20 : there is no such number as IXX.)
- A bar placed on top of a letter or string of letters increases the numeral's value by 1,000 times.

  For example, XII = 12 whether XII = 12000.

2. DIGITS OF NUMBER

- **Units** : Digit 0 to 9 are called Unit digits. The smallest and the largest number of 1-digit are 0 and 9 respectively.
- **Tens** : The numbers from 10 to 99 are called ten numbers. The smallest and the largest number of 2-digits are 10 and 99 respectively.
- **Hundreds** : The numbers from 100 to 999 are called hundred numbers. The smallest and the largest number of 3-digits are 100 and 999 respectively.
- **Thousands :** The numbers from 1,000 to 9,999 are called thousand numbers. The smallest and the largest number of 4-digits are 1000 and 9999 respectively.

- **Ten thousands :** The numbers from 10,000 to 99,999 are called ten thousand numbers. The smallest and the largest number of 5-digits are 10,000 and 99,999 respectively.
- **Lakhs :** The numbers from 1,00,000 to 9,99,999 are called lakh numbers. The smallest and the largest number of 6-digits are 1,00,000 and 9,99,999 respectively.
- **Ten Lakhs :** The numbers from 10,00,000 to 99,99,999 are called ten lakh numbers. The smallest and the largest number of 7-digits are 10,00,000 and 99,99,999 respectively.
- **Crores :** The numbers from 1,00,00,000 to 9,99,99,999 are called crore numbers. The smallest and the largest number of 8-digits are 1,00,00,000 and 9,99,99,999 respectively.

3. VALUE OF DIGITS

- **Place Value–**Place value helps us determine the value of numbers. Our (base-10) number system contains numerals or digits only from 0 to 9, but we often need to use numbers greater than 9. We show numbers greater than 9 by using place value. Place value refers to the value of each digit in a number.

  Example : In a number 489765, place value of 7 will be 7×100 units, *i.e.*, 700. Similarly, the place value of 8 will be $8 \times 10,000 = 80,000$.

- **Face Value–**The actual value of a digit in a number is the digit itself. The place value of the digit is ignored in the number.

  Example : In a number 59,438, the face value of 4 is 4, face value of 9 is 9 etc.

Note

If x and y be the tens digit and unit digit respectively, then the 2-digit number formed by these digits will be $10x + y$.

4. COMPARISON OF NUMBERS

- **When both numbers have unequal number of digits**

  The number having more digits is greater. It means

  ..... 5-digit number > 4-digit number > 3-digit number .....

  Example : Find out which is greater 5429683 or 65245893 ?

  Solution : Since, the first number 5429683 is of 7-digit number whether the second number 65245893 is of 8-digit. Therefore, the second number is greater than the first number.

- **When both numbers have equal number of digits**

  In case of the equal number of digits, we have to check the place value of the left-most digit of both numbers. If the digits of both numbers are also equal, then we move to its next digit placed on the right side and repeat the process until we get the desired result.

  Example : Arrange the following numbers in ascending order.

  5403100, 5460860, 5458087, 5420378

  Solution : At first, we check the place value of the leftmost digit of each number. Then repeat the same process until we get the answer. Here, in each number, two leftmost digits are equal. After that, we check ten thousand place values and then arrange the digits in ascending order. Hence, we get

  5403100 < **542**0378 < **545**8087 < **546**0860

5. CLASSIFICATION OF NUMBERS

There are several types of numbers exist in the number system for different purposes. These numbers are classified into different groups according to their properties. These are :

- **Natural Numbers** : Counting numbers starting from 1, 2, 3…, etc. are called natural numbers. It is represented by capital letter **N**. Its set is shown as

  $$N = \{1, 2, 3, 4, 5\ldots\}$$

- **Whole Numbers** : All natural numbers along with 0 is known as whole numbers. It is represented by capital letter **W**. Its set is shown as

  $$W = \{0, 1, 2, 3, 4\ldots\}$$

- **Even and Odd Numbers** : A number is even if it is a multiple of two, and is odd otherwise. Even numbers are denoted by capital letter **E** and odd numbers are denoted by capital letter **O**.

  $E = \{2, 4, 6, 8\ldots\}$ and $O = \{1, 3, 5, 7\ldots\}$

- **Integers** : Positive and negative counting numbers, as well as zero are called integers. Integers are denoted by capital letter Z.

  $$Z = \{\ldots -3, -2, -1, 0, 1, 2, 3\ldots\}$$

  O is neither a positive nor a negative integer.

- **Prime Numbers** : An integer with exactly two positive divisors itself and 1, is called prime number. For example : 2, 3, 5, 7, 11, 13…etc. are few prime numbers. 2 is the smallest prime number.

- **Composite Numbers** : All those numbers greater than 1 that are not prime are called composite numbers. For example : 4, 6, 8, 9, 10 etc. are few composite numbers.

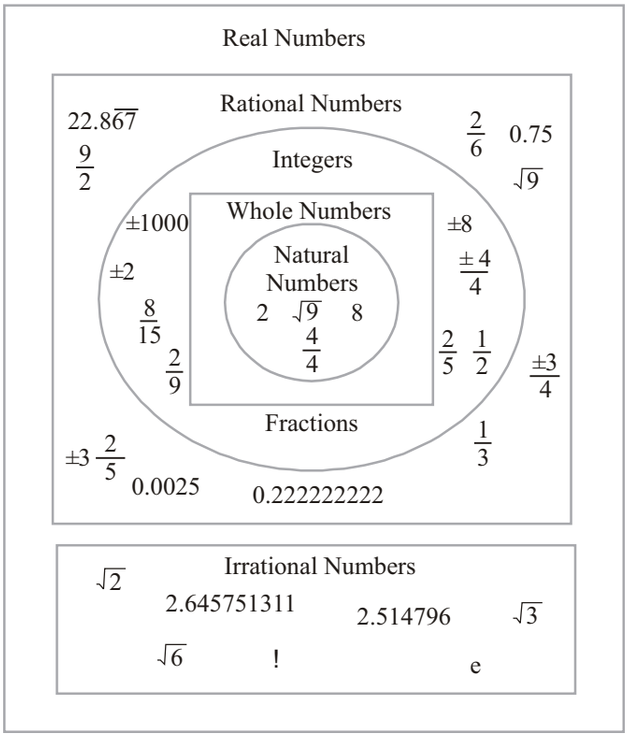
- **Rational Numbers** : Numbers that can be expressed as a ratio of an integer to a non-zero integer. Rational numbers are denoted by capital letter **Q**. All integers are rational, but the converse is not true.

  $$Q = \left\{\ldots \frac{2}{3}, -1, 0, \frac{1}{4}\ldots\right\}$$

- **Irrational Numbers** : All the real numbers that are not rational are called irrational numbers. Irrational numbers are denoted by **I**.

  $$I = \left\{\ldots \frac{2}{3}, \sqrt{2}, \sqrt{3}\ldots\right\}$$

- **Real Numbers**–They can be positive, negative or zero. All rational numbers are real, but the converse is not true.



6. APPROXIMATE VALUES OF NUMBERS

Place values are considered to be the base to find approximation values in numbers. Approximation value of few place values is determined by the following methods.

- **Approximate value nearest tens place**–If the number at units place is less than 5 then it is rounded of zero otherwise add 1 to the tens place and keeps unit place as zero.

  Example : 73 can be rounded off to 70, 156 can be rounded off to 160 and 4265 can be rounded off to 4270.

- **Approximate value nearest hundred place**–If the number at tens place is less than 5 then it is rounded of zero otherwise add 1 to the hundred place and keeps tens place and unit place as zero.

  Example : 510 can be rounded off to 500, 9573 can be rounded off to 9600 and 53650 can be rounded off to 53700.

- **Approximate value nearest thousand place**–If the number at hundred place is less than 5 then it is rounded of zero otherwise add 1 to the thousand place and keeps hundred place, tens place and unit place as zero.

  Example : 6240 can be rounded off to 6000, 17573 can be rounded off to 18000 and 553650 can be rounded off to 554000.

7. DIVISIBILITY TEST OF NUMBERS

- **Divisibility by 2 :**

  If the unit digit of a number is any of 0, 2, 4, 6, 8, then the given number is divisible by 2.

  Example : 84, 786, 282, 1008, 5000….., etc. are divisible by 2.

- **Divisibility by 3 :**

  A number is divisible by 3, if the sum of all digits of the number is divisible by 3.

  Example : 786, here 7 + 8 + 6 = 21 (completely divisible by 3)

  So, the number 786 will be divisible by 3.

- **Divisibility by 4 :**

  A number is divisible by 4, if the last two-digits of the number is divisible by 4.

  Example : 3464, here 64 is the last two-digit number which is divisible by 4.

  So, the number 3464 will be divisible by 4.

- **Divisibility by 5 :**

  A number is divisible by 5, if the unit digit of the number is either 0 or 5.

  Example : 3125, 2010, 2015, 6580……, etc. are divisible by 5.

- **Divisibility by 6 :**

  A number is divisible by 6, if the number is divisible by the numbers 2 and 3.

  Example : Test whether number 8202 is divisible by 6.

  Solution : (i) the unit digit of the number is 2 which is divisible by 2.

  (ii) the sum of digits of the number = 8 + 2 + 0 + 2 = 12 (divisible by 3)

  Since, it is clear from (i) and (ii) that the number 8202 is divisible by both 2 and 3. So, the number will be divisible by 6.

- **Divisibility by 7 :**

  Take the last digit of the given number and double it. Subtract this number from the rest of the digits in the original number. If this new number is either 0 or if it is a number that is divisible by 7, then the given number is also divisible by 7.

  Example : Test whether number 2492 is divisible by 7.

  Solution : Here, the unit digit of the number = 2

  $249 - 2 \times 2 = 245$ (divisible by 7). So, the number will be divisible by 7.

- **Divisibility by 8 :**

  A number is divisible by 8, if the last three-digits of the number is divisible by 8.

  Example : Test whether number 6288 is divisible by 8.

Solution : Here, in the given number, 288 is the last three-digit number which is completely divisible by 8.

So, the number 6288 will be divisible by 8.

- **Divisibility by 9 :**

A number is divisible by 9, if the sum of its digits is divisible by 9.

Example : Test whether number 7074 is divisible by 9.

Solution : Sum of all digits of the number = 7 + 0 + 7 + 4 = 18 (divisible by 9).

So, the number 7074 will be divisible by 9.

- **Divisibility by 11 :**

A number is divisible by 11, if difference between the sum of digits at odd places and the sum of digits at even places, is divisible by 11.

Example : Test whether number 86460 is divisible by 11.

Solution : Sum of the all digits at even places in the number = 6 + 6 = 12

Sum of the all digits at odd places in the number = 8 + 4 + 0 = 12

Their difference = 12 – 12 = 0. So, the number 86460 will be divisible by 11.

8. DIVISION ALGORITHM

The number which we divide is called the dividend. The number by which we divide is called the divisor. The result obtained is called the quotient. The number left over is called the remainder. Some formula are given below for Division based questions.

- Dividend = Divisor × Quotient + Remainder
- $\text{Divisor} = \dfrac{\text{Dividend} - \text{Remainder}}{\text{Quotient}}$
- $\text{Quotient} = \dfrac{\text{Dividend} - \text{Remainder}}{\text{Quotient}}$

Example : In a question, the divisor is 4 times the quotient and 2 times the remainder. If the remainder is 20, then find the value of dividend.

Solution : According to Question,

Divisor = 2 × Remainder = 2 × 20 = 40 …(1)

And, Divisor = 4 × Quotient

$\Rightarrow$ 4 × Quotient = 40 [from eq.(1)]

$\Rightarrow$ Quotient = 40/4 = 10

$\therefore$ Dividend = 40 × 10 + 20 = 400 + 20 = 420

9. WHOLE NUMBERS

We start counting from the number 1. Hence 1 is the first natural number and the next natural number is 2 which is obtained by adding 1 to the first number. Hence, numbers are represented in two ways according to their orderliness :

- **Predecessor** : The natural number immediately preceding a natural number is its predecessor.

Example : Predecessor number of 65 = 65 – 1 = 64

Predecessor number of 127 = 127 – 1 = 126

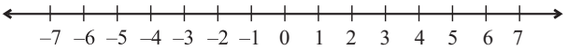
- **Successor** : The natural number immediately next to any natural number is its successor.

Example : Successor number of 785 = 785 + 1 = 786

Successor number of 109 = 109 + 1 = 110

10. INTEGERS

The set of all negative numbers and positive numbers on either side of the zero marked on the number line is called an integer. –5, – 4, – 3, –2, –1, 0, 1, 2, 3, 4, and 5 all are the integers. On the number line, integers are represented as follows :



$= \dfrac{795}{13} = 53$

I. Properties of Integers :

(i) Closure Property (For addition, subtraction and multiplication)—The sum of any two integers is always an integer and we say that integers are close for addition.

If a and b are two integers, then $(a + b)$, $(a - b)$ and $(a \times b)$ will also be integers.

Example :

4 + 5 = 9	Integer
4 × 5 = 20	Integer
4 – 5 = – 1	Integer
$4 \div 5 = \dfrac{4}{5}$	Not Integer

It is clear that division of integers does not follow the closure law.

(ii) Commutative Property (For addition and multiplication)—If a and b are two integers, then

- $(a + b) = b + a$
- $a * b = b * a$

Example : 4 + 5 = 9 = 5 + 4

4 × 5 = 20 = 5 × 4

4 – 5 = – 1 ≠ 5 – 4

$4 \div 5 = \dfrac{4}{5} \neq 5 \div 4$

It is clear that subtraction and division of integers do not follow the commutative property.

(iii) Associative Property (For Addition and Multiplication)—If a, b and c are three integers, then

- $(a + b) + c = a + (b + c)$
- $(a * b) * c = a * (b * c)$

Example : 4 + (5 + 6) = 15 = (4 + 5) + 6

4 * (5 * 6) = 120 = (4 * 5) * 6

(iv) Distributive Property (For addition and multiplication)—If a, b and c are three integers, then

$(a + b) * c = (a * c) + (b * c)$

Example : $(4 + 5) * 6 = (4 * 6) + (5 * 6)$

$9 * 6 = 24 + 30$

$54 = 54$

(v) Identity Element (For addition and multiplication)—

- **Additive Identity—** '0' (zero) is called the additive identity for integers, because we get the same number on adding zero to the number.

  Example : $4 + 0 = 4$, Integer

  $5 + 0 = 5$, Integer

- **Multiplicative Identity—**'1' is called the multiplicative identity.

  Example : $4 \times 1 = 4$, Integer

  $5 \times 1 = 5$, Integer

II. Multiplication Operation of Integers :

(i) Product of (+) integer and (–) integer

$a * (-b) = -ab$

Example : $3 * (-4) = (-4) + (-4) + (-4) = -12$

By using this method, we can say that we get a negative integer on multiplying a positive integer and a negative integer.

$\therefore \quad (-4) \times 3 = -12$ (Also, in reverse order)

(ii) Product of (–) integers :

$(-a) * (-b) = (-b) * (-a) = ab$

Example : $(-15) * (-4) = 60$

$(-4) * (-15) = 60$

(iii) $a * 0 = 0 * a = 0$ (For all integers)

11. TO FIND UNIT'S DIGIT

Following is the method to find the unit digit in product of numbers and in power form of number :

I. In Product of Numbers - We find the product of unit digits of all numbers to find the unit digit in the product of numbers. The unit digit of obtained product is equal to the unit digit in product of given numbers.

Example : Find the unit digit in product of $786 \times 78 \times 687$

Solution : Here, we multiply the unit digits of all numbers in $786 \times 78 \times 687$.

= Unit digit in $6 \times 8 \times 7$

= Unit digit in $336 = 6$

So, 6 will be the unit digit in the given product.

II. In Exponential Number :

(i) For odd numbers : When unit digit is an odd number excluding 5, then

$(\times\times\times 1)^n = (\times\times\times 1)$

$(\times\times\times 3)^{4n} = (\times\times\times 1)$

$(\times\times\times 7)^{4n} = (\times\times\times 1)$

$(\times\times\times 9)^n = (\times\times\times 1)$, if n is an even number

$= (\times\times\times 9)$, if n is an odd number.

Example : Find the unit digit in $(27)^{43}$

Solution : Unit digit in $(27)^{43}$

= Unit digit in $(7)^{43}$

= Unit digit in $(7)^{4 \times 10 + 3}$

= Unit digit in $(7)^3$

= 3

(ii) For Even numbers :

$(\times\times\times 2)^{4n} = (\times\times\times 6)$

$(\times\times\times 4)^{2n} = (\times\times\times 6)$

$(\times\times\times 6)^n = (\times\times\times 6)$

$(\times\times\times 8)^{4n} = (\times\times\times 6)$

Example : Find the unit digit in $(44)^{69}$

Solution : Unit digit in $(44)^{69}$

= Unit digit in $(4)^{69}$

= Unit digit in $(4)^{2 \times 34 + 1}$

= Unit digit in $(6 \times 4) = 4$

Note

If unit digits of a number is 0, 1, 5 and 6, then the unit digit in exponent of that number will also be 0, 1, 5 and 6 respectively.

12. IMPORTANT FACTS

- Sum of natural number from 1 to $n = \dfrac{n(n+1)}{2}$

Example : Find the sum of first 25 natural numbers.

Solution : Required sum $= \dfrac{n(n+1)}{2}$

$= \dfrac{25(25+1)}{2}$ $(\because n = 25)$

$= 25 \times 13 = 325$

- Sum of first n even numbers $= n(n + 1)$

Example : Find the sum of first 10 even numbers.

Solution : Required sum $= n(n + 1)$

$= 10(10 + 1)$

$= 10 \times 11 = 110$

- The sum of first n odd numbers $= n^2$

Example : Find the sum of first 7 odd numbers.

Solution : Required sum $= n^2$

$= (7)^2 = 49$

- Sum of squares of first n natural numbers

$$(s) = \frac{n(n+1)(2n+1)}{6}$$

Example : What will be the sum of squares of first 12 natural numbers ?

Solution : Required sum $= \dfrac{n(n+1)(2n+1)}{6}$

$= \dfrac{12(12+1)(2\times12+1)}{6}$

$= 2 \times 13 \times 25 = 650$

- Sum of squares of even numbers from 1 to n

$$= \frac{n(n+1)(n+2)}{6}$$

Example : What will be the value of $2^2 + 4^2 + 6^2 + ... + 18^2 + 20^2$?

Solution : $n = 20$

$$\text{Required Sum} = \frac{20(20+1)(20+2)}{6}$$

$$= \frac{20 \times 21 \times 22}{6} = 1540$$

- Sum of squares of odd numbers from 1 to n.

$$= \frac{n(n+1)(n+2)}{6}$$

Example : What will be the value of $1^2 + 3^2 + 5^2 + ... + 19^2 + 21^2$.

Example : $n = 21$

$$\text{Required sum} = \frac{n(n+1)(n+2)}{6}$$

$$= \frac{21 \times 22 \times 23}{6} = 1771$$

- Sum of cubes of first n natural numbers

$$(s) = \left[\frac{n(n+1)}{2}\right]^2$$

Example : What will be the sum of cubes of first 5 natural numbers ?

Solution : Required sum $= \left[\frac{n(n+1)}{2}\right]^2$

$$= \left[\frac{5 \times (5+1)}{2}\right]^2$$

$$= (5 \times 3)^2 = (15)^2 = 225$$

- Total No. of n digit $= 9 \times 10^{n-1}$

Example : Find the total number of two digit number between 1 to 100.

Solution : Required numbers $= 9 \times 10^{n-1}$

$\because$ Here $n = 2$,

$\therefore$ Numbers $= 9 \times 10^{(2-1)}$

$= 9 \times 10 = 90$

Note

- The sum and the difference of two odd numbers is always on even number.
- The sum and the difference of two even numbers is always an even numbers.
- The sum and the difference of an even number and an odd number is always an odd number.
- The multiplication of two even numbers is always an even number.
- The multiplication of an even number and an odd numbers is always an even number.
- The sum, difference and multiplication of two rational numbers is a rational number.
- The sum, difference multiplication and division of a rational and an irrational is always an irrational.

Important Questions

1. If the sum of five consecutive integers be S, then how is the greatest of these integers related to S?

(A) $\frac{S-10}{5}$ (B) $\frac{S+4}{4}$

(C) $\frac{S+5}{4}$ (D) $\frac{S+10}{5}$

2. If $\frac{1}{2}$ is subtracted from a number and difference is multiplied by 8, the result is What is this number?

(A) 2 (B) 3

(C) 4 (D) 8

3. If $1^3 + 2^3 + 3^3 + 4^3 + ... + n^3 = \left[n\left(\frac{n+1}{2}\right)\right]^2$ where 'n' is a natural number, then $1^3 - 2^3 + 3^3 - 4^3 + 5^3 - 6^3 + 7^3 - 8^3 + 9^3 - 10^3$ is equal to :

(A) 3025 (B) – 575

(C) – 1800 (D) 2425

4. What is the greatest value of A for which the 6 digit number 326A50 is divisible by 3?

(A) 2 (B) 6

(C) 8 (D) 9

5. The number of zeros at the end of number $1 \times 2 \times 3 \times 4 \times .....\times 20$, is :

(A) 6 (B) 4

(C) 5 (D) 3

6. If alphabets A, B, C, ... are represented by numbers 1, 2, 3, ..., then the value of $\sqrt{Z - A}$, is :

(A) 5 (B) 4

(C) 7 (D) 11

7. Which of the following is the correct representation, using Roman Numerals of the number 199?

(A) ICC (B) CLXXXXIX

(C) CXCIX (D) ICCCD

8. A number written using Roman Numerals (XXI – XV) – VI + MCLXXIII is equal to :

(A) MCLXXIII (B) MCLXVII

(C) MCL (D) MCXLIII

9. The sum of all prime number, less than 21, is :

(A) 77 (B) 67

(C) 41 (D) 48

10. Which of the following statements are NOT correct?

(1) Composite numbers are always even

(2) Prime numbers are always odd.

(3) Sum of two prime numbers is always prime.

(4) Product of two composite numbers is always composite.

(A) 1 and 4 only

(B) 2 and 3 only

(C) 1, 2 and 3 only

(D) 1, 2, 3 and 4

11. Which of the following numbers is divisible by 3 ?

(A) 518932 (B) 117342

(C) 213454 (D) 337625

12. The expenditure of a family per month is as follows :

Kitchen = ₹ 9,378

Education = ₹ 3,780

Conveyance = ₹ 2,817

Sundry Expenses = ₹ 4,388.

Rounded off total monthly expenditure of the family to the nearest thousand is :

(A) ₹ 21,000 (B) ₹ 24,000

(C) ₹ 20,000 (D) ₹ 23,000

13. 30009 is same as :

(A) 30 ten thousands and 9 tens

(B) 30 thousands and 9 hundreds

(C) 3 ten thousands and 9 ones

(D) 3 ten thousands and 9 tens

14. Sumit weighs 107 kg and Sanjay weighs 82 kg. The difference of their weight if the weight of each is rounded off to the nearest tens is :

(A) 30 kg (B) 100 kg

(C) 40 kg (D) 20 kg

15. The sum of the digits of a number is subtracted from the number. The resulting number is always divisible by :

(A) 2 (B) 7

(C) 5 (D) 9

16. I am a prime number. If you subtract 1 from me, I will become divisible by 9. Who am I ?

(A) 29 (B) 19

(C) 17 (D) 11

17. The smallest composite number is :

(A) 4 (B) 1

(C) 9 (D) 6

18. The sum of all prime numbers between 58 and 68 is :

(A) 179 (B) 178

(C) 187 (D) 183

19. How many three-digit numbers are there in all ?

(A) 900 (B) 999

(C) 499 (D) 566

20. The difference between the predecessor and the successor of one million is _____

(A) 1 (B) 2

(C) 1,000,000 (D) 1000001

21. The sum of three consecutive odd numbers is always divisible by :

(A) 3 (B) 9

(C) 15 (D) 21

22. The smallest 5-digit number that is divisible by 19 is :

(A) 10019 (B) 10013

(C) 10032 (D) 10000

23. The least number of 4 digits exactly divisible by 7 is :

(A) 1007 (B) 1001

(C) 1,006 (D) 1009

24. When a number is divided by 221, the remainder is 64. If the same number is divided by 13, what will be the remainder ?

(A) 0 (B) 1

(C) 2 (D) 12

25. On dividing a number by 38, we get 90 as a quotient and 19 as a remainder. What is the number ?

(A) 3401 (B) 3382

(C) 3458 (D) 3439

26. What will be the remainder on dividing $141 \times 142 \times 143$ by 6 ?

(A) 0 (B) 2

(C) 4 (D) 5

27. How many natural numbers are there between 1000 and 2000, which divided by 341, leaves remainder 5 ?

(A) 3 (B) 2

(C) 4 (D) 1

28. What is the smallest five-digit number divisible by 123 ?

(A) 10037 (B) 10086

(C) 10081 (D) 10063

29. A number when divided by the sum of 555 and 445 gives two times their difference as quotient and 30 as the remainder. Find the number.

(A) 220030 (B) 22030

(C) 122030 (D) 12500

30. The last 2 digits of a 200 digit number 123012300123000123000.....are :

(A) 00 (B) 01

(C) 12 (D) 23

31. How many digits are required to write numbers from 1 to 50 ?

(A) 100 (B) 92

(C) 91 (D) 50

32. Two positive integers are such that the sum of first number and twice the second number is 8 and their difference is 2. Find the numbers.

(A) 7, 5 (B) 3, 5

(C) 6, 4 (D) 4, 2

33. In an exam, the sum of the scores of A and B is 120, that of B and C is 130 and that of C and A is 140. What is the score of C ?

(A) 70 (B) 75

(C) 60 (D) 65

34. The sum of three numbers is 2. First number is $\frac{1}{2}$ times of second number and third number is $\frac{1}{4}$ times the second number. What will be the second number ?

(A) $\frac{7}{6}$ (B) $\frac{8}{7}$

(C) $\frac{9}{8}$ (D) $\frac{10}{9}$

35. If the arithmetic mean of $3a$ and $4b$ is greater than 50 and a is twice of b, then what will be the smallest possible integer value of a ?

(A) 18 (B) 19

(C) 20 (D) 21

36. If the digits in the unit and tens place of a two-digit number are interchanged, then the new number is 63 more than the original number. Suppose the digit in the unit plce of the original number be x then all the possible values of x will be :

(A) 7, 8, 9 (B) 2, 7, 9

(C) 0, 1, 2 (D) 1, 2, 8

37. The sum of a two-digit number and the number formed by reversing its digits is a perfect square number, then how many of such number exists ?

(A) 5 (B) 6

(C) 7 (D) 8

38. The height of a tree increases every year $\frac{1}{8}$ of its height. If the present height of tree is 64 cm, then what will be its height after 2 years ?

(A) 72 cm (B) 74 cm

(C) 75 cm (D) 81 cm

39. 380 mangoes are distributed among some boys and girls who are 85 in numbers. Each boy gets 4 mangoes and each girl gets 5 mangoes, then find the number of boys.

(A) 15 (B) 38

(C) 40 (D) 45

40. Doubling a number and adding 20 to the result gives the same answer as multiplying the number by 8 and taking away 4 from the product. Find the number.

(A) 2 (B) 3

(C) 4 (D) 6

41. In competitions of race, there is a run of 100 yards as well as 100 metres. How many metres is 100 metres more than 100 yards ?

(A) 0.856 metre (B) 8.56 metres

(C) 0.0856 metre (D) 1.06 metres

42. In a parking area, the total number of wheels of all the cars and bikes is 100 more than twice the number of parked vehicles. Find the number of parked cars :

(A) 35 (B) 45

(C) 50 (D) 55

43. The product of digits of a two-digit number is 24. If we add 45 to the number, then the new number obtained is the number in which the digits are interchanged. What is the original number ?

(A) 54 (B) 83

(C) 38 (D) 45

44. 1800 chocolates were distributed among students in a class. Each student gets the chocolates twice the number of students in the class. Find the number of students in the class.

(A) 30 (B) 40

(C) 60 (D) 90

45. The sum of three numbers is 252. If first number is thrice the second number and third number is two-third of first number then what will be the second number ?

(A) 41 (B) 21

(C) 42 (D) 84

46. In a two-digit number, the digit at units place is twice the digit at tens place and if 2 is subtracted from the sum of both digits, then the difference is equal to the $\frac{1}{6}$ times of the number. What is the number ?

(A) 26 (B) 25

(C) 24 (D) 23

47. The sum of three consecutive even numbers is always divisible by.....

(A) 12 (B) 6

(C) 18 (D) 24

48. The product of all prime numbers between 80 and 90 will be :

(A) 83 (B) 89

(C) 7387 (D) 598347

49. An owner of motorcar reduced his monthly usage of C.N.G. on increasing the price of C.N.G. Price-usage relation is following :

Price (₹/Litre)	C.N.G. (in litres)
40	60
50	48
60	40
75	32
80	?

Then find the value of :

(A) 30 (B) 28

(C) 26 (D) 24

50. If the sum of digits of any integer lying between 100 and 1000 is subtracted from the same integer, the resulting number is always divisible by which of the following number ?

(A) 2 (B) 5

(C) 6 (D) 9

51. If a 4-digit number $2x\,y8$ is exactly divisible by 3, then which of the following is the least value of $(x + y)$?

(A) 2 (B) 4

(C) 6 (D) 5

52. Find the digits A and B if

$$\begin{array}{r} B\ A \\ \times\ A\ 4 \\ \hline 1\ 3\ A\ 0 \end{array}$$

(A) 5, 4 (B) 5, 2

(C) 4, 5 (D) 2, 5

53. Which of the following can give the result as 'the square of a natural number 'n' ?

(A) Sum of the squares at first n natural numbers.

(B) Sum of the first n natural numbers.

(C) Sum of the first $(n - 1)$ natural numbers.

(D) Sum of the first 'n' odd natural numbers

54. X is a two-digit number, Y is the number obtained on reversing the digits of X. Which of the following is true ?

(A) X + Y is divisible by 10.

(B) X – Y is divisible by 6.

(C) X – Y is divisible by 9.

(D) X + Y is divisible by 8.

55. The unit place digit in 9^{201} is :

(A) 9 (B) 7

(C) 3 (D) 1

56. Which of the following is not true ?

(A) 8/7 + 3/8 = 3/8 + 8/7

(B) 8/7 × 3/8 = 3/8 × 8/7

(C) 8/7 / 3/8 = 8/7 × 8/3

(D) 8/7 – 3/8 = 3/8 – 8/7

57. The product of a non zero rational number and its reciprocal is _____.

(A) 1

(B) 0

(C) rational number itself

(D) reciprocal of rational number

58. How many natural numbers exist between the squares of 28 and 29 ?

(A) 30 (B) 58

(C) 56 (D) 60

59. Which one of the following will have odd unit digit ?

(A) 52^2 (B) 56^2

(C) 57^2 (D) 58^2

60. The unit digit in cube of 143 is :

(A) 1 (B) 3

(C) 7 (D) 9

61. The nature of $(-5 + 2\sqrt{5} - \sqrt{5})$ is :

(A) natural (B) integer

(C) rational (D) irrational

62. A negative integer and a positive integer whose difference is + 2, are :

(A) – 1, 3 (B) – 2, 4

(C) – 1, 1 (D) – 4, 6

63. What will be the sum of all the numbers between 200 and 600, which will be divisible by 16 ?

(A) 9999 (B) 98360

(C) 10000 (D) 10001

64. The price of 10 chairs is equal to the price of 4 tables. The total price of 15 chairs and 2 tables is ₹ 4000. The total price of 12 chairs and 3 tables is :

(A) ₹ 3750 (B) ₹ 3840

(C) ₹ 3500 (D) ₹ 3900

65. The sum of all three digit numbers, which when divided by 5, gives a remainder of 2, is :

(A) 99810 (B) 98910

(C) 98901 (D) 89901

66. Which of the following is the value of $1^2 + 2^2 + 3^2 + \ldots\ldots\ldots\ldots + n^2$?

(A) $\frac{n(n+1)}{2}$

(B) $\frac{n(n+1)(2n-1)}{6}$

(C) $\frac{n(n+1)(2n+1)}{6}$

(D) $\frac{n^2(n+1)^2}{36}$

67. Which of the following number is divisible by 18 ?

(A) 1726 (B) 596

(C) 6426 (D) 11356

68. Between two given rational numbers, we can find.

(A) Only one rational number

(B) Only finite rational number

(C) Only five rational number

(D) Infinitely many rational number

69. The sum of a two digit number and the number obtained by reversing the digits is 55. If the digits of the number differ by 1, find the number :

(A) 32 (B) 12

(C) 76 (D) 34

70. The rational number which lies between $\sqrt{2}$ and $\sqrt{3}$ is :

(A) $\sqrt{2} \times \sqrt{3}$ (B) $\frac{\sqrt{2}+\sqrt{3}}{2}$

(C) 1.5151 (D) 1.805005

71. The sum of the first 20 multiples of 13 is :

(A) 273 (B) 2730

(C) 2600 (D) 260

72. Which of the following rational numbers have a terminating decimal expansion ?

(A) $\frac{22}{121}$ (B) $\frac{51}{10100}$

(C) $\frac{3}{51}$ (D) $\frac{17}{221}$

Solutions

1. (D) Let, the five consecutive integer be x, $x + 1$, $x + 2$, $x + 3$ and $x + 4$ respectively.

$x + x + 1 + x + 2 + x + 3 + x + 4 = S$

$\Rightarrow \quad 5x + 10 = S$

$\Rightarrow \quad x = \frac{S-10}{5}$

On adding both side of 4

$\Rightarrow \quad x + 4 = \frac{S-10}{5} + 4$

$\Rightarrow \quad x + 4 = \frac{S-10+20}{5}$

$\Rightarrow \quad x + 4 = \frac{S+10}{5}$

Hence, option (D) is correct.

2. (A) Let, Number = x

$\Rightarrow \left(x - \frac{1}{2}\right) \times 8 = 12$

$\Rightarrow \quad 8x - 4 = 12$

$\Rightarrow \quad 8x = 16$

$\Rightarrow \quad x = 2$

Hence, number is 2.

3. (B) Given, $1^3 + 2^3 + 3^3 + 4^3 + ...+ n^3 = \left[n\left(\frac{n+1}{2}\right)\right]^2$

Then,

$\Rightarrow 1^3 - 2^3 + 3^3 - 4^3 + 5^3 - 6^3 + 7^3 - 8^3 + 9^3 - 10^3$

$\Rightarrow [1^3 + 3^3 + 5^3 + 7^3 + 9^3] - [2^3 + 4^3 + 6^3 + 8^3 + 10^3]$

$\Rightarrow [1 + 27 + 125 + 343 + 729] - 2^3[1^3 + 2^3 + 3^3 + 4^3 + 5^3]$

$\Rightarrow 1225 - 2^3\left[\left\{5\left(\frac{5+1}{2}\right)\right\}\right]$ [$\because n = 5$]

$\Rightarrow 1225 - 8 \times \{15\}^2$

$\Rightarrow 1225 - 8 \times 225$

$\Rightarrow 1225 - 1800$

$\Rightarrow -575$

Hence, option (B) is correct.

4. (A) The 6 digit number 326A50 is divisible by 3.

Divisibility Rule of 3 : A number is completely divisible by 3 If the sum of its digits is divisible by 3.

Then sum of digits

$= 3 + 2 + 6 + A + 5 + 0$

$= 16 + A$

Put the value of A is 2.

$= 16 + 2$

$= 18$

Hence, 18, will be completely divisible by 3.

5. (B) The number of zero of numbers

$1 \times 2 \times 3 \times 4 \times ..... \times 20$

$1 \times 2 \times 3 \times 4 \times 5 \times 6 \times 7 \times 8 \times 9 \times 10 \times 11 \times 12 \times 13 \times 14 \times 15 \times 16 \times 17 \times 18 \times 19 \times 20$

$1\times2\times3\times4\times5\times6\times7\times8\times9\times10\times11\times$

zero zero

$12\times13\times14\times15\times16\times17\times18\times19\times20$

zero zero

Pair of the zero $= 2 \times 5 = 10$

$= 12 \times 15 = 180$

Total number of zero = 1 + 1 + 1 + 1

= 4

Hence, option (B) is correct.

6. (A) If alphabets

A B C D E F G H I J K L M N O P

↓

1

Q R S T U V W X Y Z

↓

26

The value of A = 1

The value of Z = 26

The value of $\sqrt{Z - A} = \sqrt{26 - 1}$

$= \sqrt{25}$

$= 5$

Hence, option (A) is correct.

7. (C) Roman Numerals of the number 199

$= 100 + (100 - 10) + (10 - 1)$

$= C + (C - X) + (X - I)$

$= CXCIX$

Hence, option (C) is correct.

8. (A) (XXI – XV) – VI + MCLXXIII

XXI = X + X + I

= 10 + 10 + 1 = 21

XV = X + V = 10 + 5 = 15

VI = V + I = 5 + 1 = 6

Then (XXI – XV) – VI + MCLXXIII

= (21 – 15) – 6 + MCLXXIII

= 6 – 6 + MCLXXIII

= MCLXXIII

Hence, option (A) is correct.

9. (A) Prime Number : A prime number is a whole number greater than 1 whose only factors are 1 and itself.

Prime number less than 21 = 2, 3, 5, 7, 11, 13, 17, 19

Sum of Prime number = 2 + 3 + 5 + 7 + 11 + 13 + 17 + 19

= 77

Hence, option (A) is correct.

10. (C) **Statement 1 :** Composite Number : Composite number that have more than two factors, Number that are not Prime are composite numbers because they are divisble by more than two number

(1 × 12), (3 × 4)

Composite numbers are always even – False

Statement 2 : A prime number is a whole numbers greater than 1 whose only factors are 1 and iteself

Smallest prime number is 2. Prime Numbers are always odd – False.

Statement 3 : Sum of two prime numbers = 2 + 3

= 5 (Prime number)

i.e., 3 + 5 = 8 (even number)

and 7 + 11 = 18 (even number)

Statement 4 : Product of two composite numbers = 4 × 6

= 24 (Composite number)

and 8 × 9 = 72 Composite number)

Product of two composite numbers is always composite : True,

Hence, option (C) is correct.

11. (B) Divisibility Rules of 3 : A number is completely divisible by 3 if the sum of its digits is divisible by 3.

Option (A) 518932

Sum of digits = 5 + 1 + 8 + 9 + 3 + 2
= 28

'518932' is not divisible by 3.

Option (B) 117342

Sum of digits = 1 + 1 + 7 + 3 + 4 + 2
= 18

'18' is divisible by 3.

Hence, option (B) is correct.

12. (C) Monthly expenditure of kitchen
= ₹ 9378

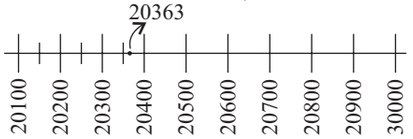
Monthly expenditure on education
= ₹ 3780

conveyance = ₹ 2817

Miscellaneous expenses = ₹ 4388

Total monthly expenses of this family = ₹ 9378 + ₹ 3780 + ₹ 2817 + ₹ 4388
= ₹ 20363

Total expenditure by family (to the nearest thousand) = 20363



Hence, total Monthly, expenditure
= ₹ 20,000

13. (C) 30009

3 × 10 thousand + 9 units
3 ten thousand + 9 units
Hence, option (C) is correct.

14. (A) Given

weight of Sumit = 107 kg
weight of rounded off to the nearest tens Sumit = 100 kg
And weight of Sanjay = 82 kg
weight of rounded off to the nearest tens of Sanjay = 80 kg
Difference weight of rounded off to the nearest tens of Sumit and Sanjay
= 110 – 80
= 30 kg

15. (D) Let, number = $10x + y$

Sum of digits = $x + y$

ATQ,

Number – Sum of digits
$= (10x + y) - (x + y)$
$= 10x + y - x - y$
$= 9x$

Factor of $9x$ are 9 and x

Number $9x$ is always divisible by 9.

16. (B) From option (A),

29 – 1 = 28

This number is not divisible by 9.

From option (B),

19 –1 =18

This number is divisible by 9

From option (C),

17.1 = 16

This number is not divisible by 9.

From option (D),

11 – 1 =10

This number is not divisible by 9.
Hence, that prime number is 19.

17. (A) Mixed numbers are exactly opposite to prime numbers which have only two factors.
That is, 1 and itself number 4 is the smallest composite number.

18. (C) The prime numbers between 58 and 68 are 59, 61 and 67.
Then sum of prime numbers
= 59 + 61 + 67
= 187
Hence, option (C) is correct.

19. (A) 3 digit numbers start from 100 and go up to 999. These numbers are made up of three digits. Then total number of 3 digits = 999 – 100 + 1
= 899 + 1
= 900

20. (B) Ten lakh = 10,00,000
Predecessor of 10,00,000
= 1000000 – 1
= 9,99,999
Successor of 10,00,000
= 10,00,000 + 1
= 10,00,001
Difference predecessor and successor of ten lakh
= 10,00,001 – 9,99,999
= 2

21. (A) Let three consecutive odd numbers.
$x - 2$ are x and $x + 2$.
Sum of three consecutive odd numbers = $x - 2 + x + x + 2$
$= 3x$
The sum of three consecutive odd numbers is always divisible by 3.
Hence, option (A) is correct.

22. (B) Smallest 5 digit number = 10000

```
19) 10000 (526
   - 95
     50
   - 38
     120
   - 114
       6
```

The smallest 5 digit number that is divisible by 19.
=10000+ (19 – 6)
= 10000 + 13
= 10013

23. (B) Smallest 4 digit number = 1000

```
7) 1000 (142
   - 7
     30
   - 28
     20
   - 14
      6
```

Smallest 4 digit number that is exactly divisible by 7
= 1000+ (7– 6)
= 1001

24. (D) **By Logical Method,**

$\because$ 13 is a factor of 221

$\therefore$ Remainder obtained on dividing, the remainder 64 again by 13 = 12

25. (D) **By Remainder Theorem,**

Dividend = Divisor × Quotient + Remainder
= 38 × 90 + 19
= 3420 + 19
= 3439

26. (A) 141 = 3 × 47 and 142 = 2 × 71

$\therefore \quad \frac{141 \times 142 \times 143}{6}$

$= \frac{3 \times 47 \times 2 \times 71 \times 143}{6}$

which is exactly divisible by 6, so remainder = 0

27. (A) According to the question,

First number = 341 × 3 + 5
= 1023 + 5 = 1028
Second number = 341 × 4 + 5
= 1364 + 5 = 1369
Third number = 341 × 5 + 5
= 1705 + 5 = 1710
Fourth number = 341 × 6 + 5
= 2046 + 5
= 2051

which is greater than 2000
So, required natural numbers between 1000 and 2000 = 3

28. (B) $\because$ Smallest number of 5 digits
= 10000

$\therefore \quad 10000 = 123 \times 81 + 37$

So, required number
= 10000 – 37 + 123
= 10086

29. (A) **By Logical Method,**

Number = divisor × quotient + remainder

$= (555 + 445) \times 2\ (555 - 445) + 30$

$= 1000 \times 220 + 30$

$= 220000 + 30 = 220030$

30. (A) By general understanding,

In the given 200 digit number, zero are increasing after 123 digits. So it is clear that last digit will also be 100 of the above number.

31. (C) Number of digits

1 to 9	$-1 \times 9 =$	9
10 to 19	$-2 \times 10 =$	20
20 to 29	$-2 \times 10 =$	20
30 to 39	$-2 \times 10 =$	20
40 to 49	$-2 \times 10 =$	20
50	$-2 \times 1 =$	2
	Total digits =	91

32. (D) According to the question,

$x + 2y = 8$ ....(i)

$x - y = 2$ ....(ii)

On solving equations (i) and (ii),

$y = 2$

and $x = 4$

So, positive integer = 4, 2

33. (B) According to question,

$A + B = 120$ ....(i)

$B + C = 130$ ....(ii)

$C + A = 140$ ....(iii)

On adding eqns. (i), (ii) and (iii)

$2(A + B + C) = 390$

$A + B + C = 195$ ....(iv)

On subtracting eq. (i) from eq. (iv),

$C = 195 - 120 = 75$

34. (B) Let,

Third number $= x$

$\therefore$ Second number $= 4x$

$\therefore$ First number $= 2x$

Now, $2x + 4x + x = 2$

$\Rightarrow \quad x = \frac{2}{7}$

$\therefore$ Second number $= 4 \times \frac{2}{7} = \frac{8}{7}$

35. (D) $a = 2b$ and

$\frac{3a + 4b}{2} > 50$

$\Rightarrow \quad 3a + 2a > 100$

$\Rightarrow \quad 5a > 100$

$\Rightarrow \quad a > 20$

So, Required value = 21

36. (A) Let, two-digit number $= 10y + x$

According to the question,

$10x + y - (10y + x) = 63$

$9x - 9y = 63$

$x - y = 7$

So, it is clear that, we will get

$y = 0, 1, 2$ for $x = 7, 8, 9$

37. (D) Let, two-digit number $= 10x + y$

According to the question,

$10x + y + 10y + x =$ perfect square number

$\Rightarrow \quad 11(x + y) =$ perfect square number

So, the value of $x + y$ must be 11 to be a perfect square number.

$\therefore$ Possible pairs—(2, 9), (9, 2), (3, 8), (8, 3), (4, 7), (7, 4), (5, 6) and (6, 5)

$\Rightarrow \quad$ Total numbers = 8

38. (D) Present height = 64 cm

Height of tree after first year

$= 64 + \frac{1}{8}\ 64 = 72$ cm

Height of tree after second year

$= 72 + \frac{1}{8}\ 72 = 81$ cm

39. (D) Let, number of boys $= x$

and number of girls $= y$

So, $x + y = 85$ ...(i)

$\because$ Number of mangoes, each boy got = 4

Number of mangoes, each girl got = 5

Now, according to the question,

$\therefore \quad 4x + 5y = 380$ ...(ii)

On solving equations (i) and (ii)

$x = 45$

40. (C) Let the number be x.

According to the question,

$2x + 20 = 8x - 4$

$\Rightarrow \quad 6x = 24$

$\Rightarrow \quad x = 4$

So, the number is 4.

41. (B) $\because$ 1 yard = 36 inch

and 1 inch = 2.54 cm

$\therefore$ 1 yard $= 36 \times 2.54$ cm

$\therefore$ 100 yard $= \frac{36 \times 2.54}{100}$ 100 metre

$= 91.44$ m

So, $100 - 91.44 = 8.56$ m

42. (C) Let the number of cars be x and number of scooters be y

According to the question,

$4x + 2y = 2(x + y) + 100$

$\Rightarrow \quad 4x + 2y = 2x + 2y + 100$

$\Rightarrow \quad 2x = 100$

$\Rightarrow \quad x = 50$

43. (C) Let, number $= 10x + y$

From question,

$xy = 24$ ...(i)

and $(10x + y) + 45 = 10y + x$

or $9(y - x) = 45$

or $y - x = 5$ ...(ii)

By formula,

$(y + x)^2 = (y - x)^2 + 4yx$

$= (5)^2 + 4 \times 24$

$= 25 + 96$

$\therefore \quad (y + x) = \sqrt{121}$

$\Rightarrow \quad y + x = 11$ ...(iii)

On solving equations (ii) and (iii)

$y = 8$ and $x = 3$

So, required two digit number

$= 10 \times 3 + 8 = 38$

44. (A) Let, total number of students $= m$

From question,

$m \times 2m = 1800$

$\Rightarrow \quad 2m^2 = 1800$

$\Rightarrow \quad m = \sqrt{900} = 30$

So, total number of students = 30

45. (C) Let, Second number is x, then

First number will be $3x$

$\therefore$ Third number $= 3x \times \frac{2}{3} = 2x$

From question,

$3x + x + 2x = 252$

$\Rightarrow \quad 6x = 252$

$\Rightarrow \quad x = 42$

46. (C) Let the tens digit of required number $= x$

then, Unit digit $= 2x$

$\therefore \quad$ Number $= 10x + y$

$= 10x + 2x = 12x$

From question,

$3x - 2 = \frac{1}{6} \times 12x$

$3x - 2 = 2x$

$x = 2$

$\therefore$ Required number $= 12 \times 2 = 24$

47. (B) Let, three consecutive even numbers are $2x$, $2x + 2$ and $2x + 4$. Then from question,

Sum $= 2x + 2x + 2 + 2x + 4$

$= 6x + 6$ or $6(x + 1)$

So, the sum will always be divisible by 6.

48. (C) Prime numbers between 80 and 90
$= 83, 89$
So, Product $= 83 \times 89$
$= 7387$

49. (A) $\because$ Here monthly cost of C.N.G. in each condition = ₹ 2400
$\therefore$ When price is ₹ 80, then monthly usage of C.N.G.
$$= \frac{2400}{80} = 30 \text{ litres}$$

50. (D) Let the integer between 100 and 1000
$= 100x + 10y + z$
From question,
$(100x + 10y + z) - (x + y + z)$
$= (100x - x) + (10y - y)$
$= 99x + 9y$
$= 9(11x + y)$
So, the above number will divisible by 9.

51. (A) We know that sum of all the digits of a number is divisible by 3, then the number is also divisible by 3.
$\therefore$ sum of the digits of the given number $= 2 + \underline{x} + y + 8$
$= 10 + x + y$
Now, $10 + x + y = 12$
[$\because$ 12 is divisible by 3]
$x + y = 12 - 10$
$= 2$
So, required least value of $(x + y)$ is 2.

52. (B)
$$\begin{array}{r} B\ A \\ \times\ A\ 4 \\ \hline 1\ 3\ A\ 0 \end{array}$$
A can be either 0 or 5.
If A = 0, then it does not satisfy the condition,
$\because$ A = 5
Now,
$$\begin{array}{r} B\ 5 \\ \times\ 5\ 4 \\ \hline 1\ 3\ 5\ 0 \end{array}$$
So, $54 \times 5 + 54 \times 10B = 1350$
[$\because$ B is placed in tens digit]
$54(5 + 10B) = 1350$
$5 + 10B = 25$
$10B = 20$
$B = 2$
Hence, A = 5, B = 2

53. (D) From option (A),
The sum of squares of the first n natural numbers,
$= 1^2 + 2^2 + 3^2 + ... + n^2$
Now, $n^3 - (n-1)^3 = n^3 - (n^3 - 1 - 3n^2 + 3n)$
$= 3n^2 - 3n + 1$
Put $n = 1, 2, 3, ... (n-1), n$
$1^3 - 0^3 = 3(1)^2 - 3(1) + 1$
$2^3 - 1^3 = 3(2)^2 - 3(2) + 1$
$3^3 - 2^3 = 3(3)^2 - 3(3) + 1$
$4^3 - 3^3 = 3(4)^2 - 3(4) + 1$
.....
.....
$(n-1)^3 - (n-2)^3 = 3(n-1)^2 - 3(n-1) + 1$
$n^3 - (n-1)^3 = 3(n)^2 + 3(n) + 1$
On adding
$n^3 - 0^3 = 3[1^2 + 2^2 + 3^3 + ... n^2] - 3[1 + 2 + 3 + ... + n] + [1 + 1 + 1 + ... n]$
$n^3 = 3[1^2 + 2^2 + 3^2 + ... n^2] - 3\frac{n(n+1)}{2} + n$
$3[1^2 + 2^2 + 3^2 + ... n^2] = n^3 - n + \frac{3n(n+1)}{2}$
$3[1^2 + 2^2 + 3^2 + ... n^2] = n(n^2 - 1) + \frac{3n(n+1)}{2}$
$3[1^2 + 2^2 + 3^2 + ... n^2] = n(n+1)(n-1) + \frac{3n(n+1)}{2}$
$3[1^2 + 2^2 + 3^2 + ... n^2] = n(n+1)\left[n - 1 + \frac{3}{2}\right]$
$3[1^2 + 2^2 + 3^2 + ... n^2] = n(n+1)\left[\frac{2n+1}{2}\right]$
$1^2 + 2^2 + 3^2 + ... + n^2 = \frac{n(n+1)(2n+1)}{6}$
From option (B)
Sum of first n natural numbers $= 1 + 2 + 3 + ... + n$
The obtained series is an arithmetic progression in which $a = 1$ and $d = 2 - 1 = 1$.
$1 + 2 + 3 + ... + n$
$= \frac{n}{2}[2a + (n-1) \times d]$
$= \frac{n}{2}[2 \times 1 + (n-1) \times 1]$
$= \frac{n(n+1)}{2}$
From option (C)
Sum of first $(n-1)$ natural numbers $= 1 + 2 + 3 + ... + (n-1)$
The series obtained is A.P. in which $a = 1$ and $d = 2 - 1 = 1$
$1 + 2 + 3 + ... + (n-1)$
$= \frac{(n-1)}{2}[2a + (n-1-1) \times d]$
$= \frac{(n-1)}{2}[2 \times 1 + (n-2) \times 1]$
$= \frac{n(n-1)}{2}$
From option (D)
Sum of the first 'n' odd natural numbers.
$= 1 + 3 + 5 + ... (2n-1)$
$S_n = \frac{n}{2}[2 \times 1 + (n-1)\,2]$
$= \frac{n}{2}[2 + 2n - 2]$
$= \frac{n}{2}[2n]$
$= n^2$
Hence, option (D) is correct.

54. (C) Given that X is a two digit number, then let the units digit of number X be y and the tens digit x.
So the number X = 10 x tens digit + ones digit $= 10x + y$
And the number Y is obtained by reversing the digits of X.
So the number $Y = 10y + x$
$\therefore$ $X + Y = 10x + y + 10y + x$
$= 11\,(x + y)$
Hence, X + Y is divisible by 11
and $X - Y = 10x + y - 10y - x$
$= 9x - 9y$
$= 9\,(x - y)$
Hence, X–Y is divisible by 9.
So, option (C) is correct.

55. (A) Unit's digit in 9^{201}
$=$ Unit's digit in $(3^2)^{201}$
$=$ Unit's digit in $(3^4)^{100} \times 3^2$
$=$ Unit's digit in 1×9
$= 9$

56. (D) By commulative rule of addition
$\frac{8}{7} + \frac{3}{8} = \frac{3}{8} + \frac{8}{7}$ is true
The sum any two numbers and the sum obtained by interchanging the orders of those numbers both have the same result.
By commulative rule of multiplication
$\frac{8}{7} \times \frac{3}{8} = \frac{3}{8} \times \frac{8}{7}$ is true
The product of any two numbers and the product obtalned by interchanging the orders of those numbers both have the same result
By commulative rule of division
$\frac{8/7}{3/8} = \frac{8/7}{8/3}$ is true
$\because$ $\frac{a}{b} \div \frac{c}{d} = \frac{a}{b} \times \frac{d}{c}$
option (D) $\frac{8}{7} - \frac{3}{8} = \frac{3}{8} - \frac{8}{7}$ is not true

The commulative law is not true for the difference of two numbers

i.e., $a - b \neq b - a$

57. (A) Let, non-zero rational number $= \frac{a}{b}$

$\therefore$ The reciprocal of non- zero rational numbers $= \frac{b}{a}$

According to question

The product of non-zero rational number $\frac{a}{b} \times \frac{b}{a}$ and its recipropal

Thus, the value of product of non-zero rational number and its reciprocal is equal to 'one'.

Hence, option (A) is correct.

58. (C) ATQ,

$28^2 = 784$ and $29^2 = 841$

So, first term = 784

last term = 841

Common difference = 1

No. of natural numbers

$$= \frac{l - a}{d} + 1$$

$$= \frac{841 - 784}{1} + 1$$

$$= 57 + 1$$

$$= 58$$

So that natural numbers between the squares of 28 & 29 will be

58 – 2 = 56

59. (C) On squaring 57 we will get an odd digit at its unit's place.

60. (C) $\therefore$ Unit digit in cube of 143

= Unit digit of $(3)^3$

= Unit digit of 27

= 7

61. (D) Since $\sqrt{5}$ is a irrational number so, Irrational number.

62. (C) The difference between a negative integer and a positive integer is + 2. That is, a negative integer has been subtracted from a positive integer.

From option (A) difference of – 1 and 3 = 3 – (–1) = 3 + 1 = + 4

From option (B) difference of – 2 and 4 = 4 – (–2) = 4 + 2 = + 6

From option (C) difference of –1 and 1 = 1 – (– 1) = 1 + 1 = + 2

From option (D) difference of – 4 and 6 = 6 – (– 4) = 6 + 4 = 10

Hence option (C) is correct.

63. (C) Least number divisible by 16

$= 16 \times 13 = 208$

And largest number

$= 16 \times 37 = 592$

Required sum

$= 16 \times 13 + 16 \times 14 + ... + 16 \times 37$

$= 16 (13 + 14 + ... + 37)$

$= 16 [1 + 2 + ... + 37) – (1 + 2 + ... + 12)]$

Sum of n natural numbers $= \frac{n(n+1)}{2}$

$$= 16\left(\frac{37 \times 38}{2} - \frac{12 \times 13}{2}\right)$$

$= 16 (703 – 78) = 10000$

64. (D) ATQ, 10 Chairs = 4 Tables

And 15 Chairs $= \frac{4}{10} \times 15$ Tables

= 6 Tables

Cost of

$\because$ (15 chairs + 2 tables) = ₹ 4000

$\therefore$ (cost of 8 tables = ₹ 400

[$\because$ 15 chairs = 6 tables]

$\therefore$ 12 Chairs + 3 Tables

$$= 12 \times \frac{4}{10} \text{ Tables} + 3 \text{ Tables}$$

= 4.8 Tables + 3 Tables

= 7.8 Tables

Price of 7.8 Tables $= \frac{4000}{8} \times 7.8$

= ₹ 3900

65. (B) Those three digit numbers which when divided by 5 leave a remainder of 2.

102, 107, 112, ... 999

i.e., [(5 × 20 + 2], [(5 × 21) + 2], [(5 × 22) × 2] ..... [(5 × 199) + 2]

Total numbers = 199 – 20 + 1 = 180

Required sum = [(5 × 20) + 2] + [(5 × 21) + 2] + [(5 × 22) + 2] ..... + [(5 × 199) + 2]

= 5 [20 + 21 + 22 + ... + 199] + (2 + 2 + ... 180 term) 5[(1 + 2 + 3 .... + 199) – (1 + 2 + 3 .... + 19)] + (2 × 180)

$$= 5\left[\frac{199 \times 200}{2} - \frac{19 \times 20}{2}\right] + 360$$

$= 5[199 \times 100 – 19 \times 10] + 360$

$= 5 \times 19710 + 360$

$= 98550 + 360$

$= 98910$

66. (C) $\therefore$ Sum of square of first 'n' natural numbers

$$\Sigma n^2 = \frac{n(n+1)(2n+1)}{6}$$

67. (C) If a number is divisible by 18, then the number is always divisible by 2 and 9.

- For divisible by 2 last digit must be even or zero.
- The sum of the digits of a number divisible by 9 is always divisible by 9.

From option (A),

In the number, 1726, the last digit is 6 *i.e.*, if it is an even number then 1726 is divisible by 2.

Now, 1 + 7 + 2 + 6 = 16 *i.e.*, sum of digits of the number is not divisible by 9, so 1726 is not divisible by 9.

Hence the number 1726 is not divisible by 18

From option (B),

In the number 596, the last digit is 6 *i.e.*, if is an even number then 596 is divisible by 2.

Now, 5 + 9 + 6 = 20 *i.e.*, sum of digits of the number is not divisible by 9, so 596 is not divisible by 9.

Hence the number 596 is not divisible by 18.

From option (C),

In the number 6426, the last digit is 6 *i.e.*, if it is an even number then 6426 is divisible by 2.

Now, 6 + 4 + 2 + 6 = 18 which is divisible by 9.

Hence, if the number 6426 is divisible by both 2 and 9 then this number will also be divisible by 18.

From option (D),

In the number 11356, the last digit is 6 *i.e.*, even number, then 11356 is divisible by 2. Now, 1 + 1 + 3 + 5 + 6 = 16, which is not divisible by 9.

Hence the number 11356 is not divisible by 18.

Hence option (C) is correct.

68. (D) A rational number is a number that can be expressed as the ratio of two integer, where the denominator must not be equal to zero.

There are infinitely many rational numbers between two rational numbers.

69. (A) Let, ten's digit of number = x

And Unit digit of number = y

Then Number = 10 × ten's digit + unit digit

$= 10x + y$

Now, interchange the digits of the number = $10y + x$

ATQ,

$10x + y + 10y + x = 55$

$11(x + y) = 55$

$x + y = 5$ ...(i)

And, $x - y = 1$ ...(ii)

On adding eqn. (i) and eqn. (ii)

$2x = 6$

$x = 3$

Putting the value of x in eqn.(i)

$3 + y = 5$

$y = 2$

Required number $= 10x + y$

$= 10 \times 3 + 2 = 32$

70. (C) $\because$ $\sqrt{2} = 1.414$

And $\sqrt{3} = 1.732$

Hence, the rational number between $\sqrt{2}$ and $\sqrt{3}$ is 1.5151

71. (B) Series obtained from the first 20 multiples of 13.

13, 26, 39, 52, ... upto 20

Required sum = 13 + 26 + 39 + 52 + ... + 260

= 13 (1 + 2 + ... + 20)

$= 13 \times \frac{20(20+1)}{2}$

= 13 × 10 × 21 = 2730

72. (A) Option (A), $\frac{22}{121} = 0.181818.....$

$= 0.\overline{18}$

Option (B), $\frac{51}{10100} = 0.005049$

Option (C), $\frac{3}{51} = 0.05882$

Option (D), $\frac{17}{221} = 0.076923$

Hence, terminating decimal is $\frac{22}{121}$ which value is 0.1818.

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Chapter 1 The Sentence

1. Definition

A sentence is a group of words that are arranged in a way to convey a complete and meaningful sense. *i.e.*, The boys fly kites A group of words like this which conveys complete sense is called sentence.

2. Kinds of Sentences

Sentences are of five kinds :

- Assertive/Statement/Declarative sentence.
- Interrogative sentence.
- Imperative sentence.
- Exclamatory sentence.

Assertive/Statement/Declarative sentence

[Subject + Verb + Object]

A sentence that makes only a statement or assertion and ends with a full stop. It may be affirmative or negative.

Examples :

- Vijayshree is playing in the garden.
- He may win the prize.
- I have no money.
- Shubham is not living in Noida these days.
- They never come in time.

Interrogative sentence

[Helping verb + Subject + Main verb + Object [Not necessary]

[Wh-word + Helping verb + Subject + Main verb + obj.]

A sentence that asks a question is called an **interrogative** question.

Note :

An interrogative sentence ends with a mark of interrogation [?].

Examples :

- Is that your book ?
- Do you read any newspaper ?
- Does he smoke ?
- Will she pass the examination ?
- What is your favourite colour ?
- How are you ?

Imperative sentence

[Verb Ist form/donot/always/Never/Please + Verb Ist form + ...]

A sentence that expresses a command, request, order or invitation is called an **imperative sentence.**

Note :

The subject 'you' is understood.

Examples :

- Shut the door. (Command)
- Please pass the salt. (Request)
- Do not waste food. (Advice)
- Do not pluck that flowers. (Prohibition)
- Come in time. (Order)

Exclamatory sentence

A sentence that expresses some strong and sudden feeling. The feelings can be of joy, sorrow, wonder or surprise etc.

Usually it begins with an interjection *i.e.* Alas! how! what! oh Hurrah, God etc.

Note :

The mark of exclamation [!] is put at the end of either the exclamatory word or the exclamatory sentence.

Examples :

- How beautiful ! (Joy)
- How dare you ! (Anger)
- Alas! I am undone. (Sorrow)
- What a nice case ! (Surprise)
- What a tragic end ! (Regret)

Usually it begins with an interjection *i.e.*, alas! how! what! oh, Hurrah, God etc.

Optative Sentence : A sentence that expresses a prayer, wish or desire is called on optative.

Examples :

- May you be successful! (wish)
- Wish you a happy new year! (wish)
- Would that I were a prince! (wish)
- May God bless you! (Prayer)

In English Grammar, subject and predicate are the parts of sentences. Only the combination of these two elements can complete a sentence.

Subject : The subject of the sentence is the part that names the person or things we are speaking about. *eg*.

"The dog is sleeping in the sun," **the word dog is the subject.**

Predicate : The Predicate is the part of the sentence that tells something about the subject. *eg*. "The child threw the ball," the word "threw the ball" is the predicate.

Important Questions

1. Identify the subject in the following sentence.
The Board of Directors has arrived.
(A) The Board
(B) The Board of Directors
(C) Directors
(D) The Board of

2. Which of the following is an assertive sentence ?
(A) Do you enjoy Idli Sambhar ?
(B) You are requested to stand in line.
(C) The Taj is a beautiful monument.
(D) Hurrah! the school team has won the match.

3. Which of the following is an Imperative sentence ?
(A) May God bless you my friend!
(B) They were not invited to the party
(C) Open the windows
(D) Creativity is allowing yourself to make mistakes

4. Identify the predicate in the following sentence.
He thinks that he has finished the course
(A) He
(B) thinks
(C) that he has finished the course
(D) things that he has finished the course

5. Identify the type of sentence.
Come and do your duty.
(A) Assertive (B) Interrogative
(C) Imperative (D) Exclamatory

6. Which of the following is an imperative sentence ?
(A) Feel free to text me in the evening
(B) Don't you visit your uncle's house during summer
(C) India is a land of diversity
(D) How lovely they are

7. Which of the following sentences is an exclamatory one?
(A) You are really very kind.
(B) She is small creature.
(C) He cannot speak well.
(D) How beautiful is the morning today!

Direction (Q. No. 8 to 11)
Find the 'correct subject' from the following sentences :

8. The girl ate the mango.
(A) the girl (B) ate
(C) the mango (D) None

9. I need help with this math problem.
(A) need (B) help with
(C) problem (D) I

10. Last month my grandfather came from Delhi.
(A) my grandfather
(B) last month
(C) Delhi
(D) None

11. My favourite month is July.
(A) is
(B) my favourite
(C) my favourite month
(D) July

Direction (Q. No. 12 to 15)
Find the 'correct predicate' from the following subject :

12. A glacier is a river of ice moving slowly down a mountain.
(A) A glacier
(B) is a river of ice moving slowly down
(C) a mountain
(D) None

13. A student and the bus driver were injured in the crash.
(A) were injured in the crash
(B) a student
(C) the bus driver
(D) None

14. My mom and I went shopping.
(A) my mom
(B) I
(C) went shopping
(D) and

15. I always bring my dictionary to class.
(A) always bring my dictionary to class
(B) I
(C) my dictionary
(D) None

Answer Key

1. (B) **2.** (C) **3.** (C) **4.** (B) **5.** (C)
6. (A) **7.** (D) **8.** (A) **9.** (D) **10.** (A)
11. (C) **12.** (B) **13.** (A) **14.** (C) **15.** (A)

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अध्याय 1

वर्ण-विचार

परिभाषा

- ध्वनि' शब्दों की वह आधारशिला है, जिसके बिना शब्द की कल्पना करना असंभव है । अ, आ, इ, ई आदि जब मनुष्य की वागिन्द्रिय (जिह्वा) द्वारा व्यक्त होते हैं तब ये ध्वनियाँ कहलाती हैं। इनके लिखित रूप को 'वर्ण' कहा जाता है।
- वर्ण को 'ध्वनि–चिह्न' भी कहा जाता है। अंग्रेजी भाषा के Inch और हिंदी भाषा के 'इंच' शब्द में ध्वनिगत भेद नहीं है, क्योंकि दोनों भाषाओं में समान ध्वनियाँ हैं किन्तु लिखने में दोनों की ध्वनियों के चिह्न एक-दूसरे से भिन्न होते हैं। इस प्रकार हम कह सकते हैं कि इनमें ध्वनि–भेद तो नहीं, पर वर्ण-भेद अवश्य है। ध्वनि बोली और सुनी जाती है जबकि वर्ण लिखने, पढ़ने और देखने में प्रयोग किये जाते हैं । अतः लघुतम वाग्–ध्वनि को 'वर्ण' कहा जाता है।

वर्ण का स्वरूप

- वर्ण उस मूल ध्वनि को कहा जाता है, जिसका खण्ड न हो; जैसे–अ, ई, व, च, क इत्यादि। 'दानी' शब्द की दो ध्वनियाँ हैं– 'दा' और 'नी'। इनके भी चार खण्ड हैं–द् + आ, न् + ई। इसके पश्चात् इन चार ध्वनियों को विभक्त नहीं किया जा सकता है। वास्तव में ये मूल ध्वनियाँ वर्ण या अक्षर हैं। संक्षेप में, वर्ण वह छोटी-से-छोटी ध्वनि है, जो श्रवण का विषय है और जिसे विभक्त नहीं किया जा सकता है।
- वर्ण हमारी वाणी या उच्चरित भाषा की सबसे छोटी इकाई है। इन्हीं इकाइयों के संयोग से शब्द समूह और वाक्यों की रचना होती है। स्पष्ट है कि वर्ण और उच्चारण का बड़ा ही प्रगाढ़ सम्बन्ध है। जिन्हें एक-दूसरे से अलग नहीं किया जा सकता। मूलतः हिंदी भाषा में 52 वर्ण हैं। वर्णों के उच्चारण-समूह को 'वर्णमाला' कहते हैं।

मानक हिंदी वर्णमाला

- मूलतः हिंदी में उच्चारण के आधार पर 45 वर्ण (10 स्वर + 35 व्यंजन) एवं लेखन के आधार पर 52 वर्ण (13 स्वर + 35 व्यंजन + 4 संयुक्त व्यंजन) हैं।

स्वरः अ आ इ ई उ ऊ ऋ ए ऐ ओ औ (कुल 11)
(अं)–अनुस्वार, (अः)–विसर्ग (अयोगवाह वर्ण–2)
व्यंजनः क वर्ग– क ख ग घ ङ
च वर्ग– च छ ज झ ञ
ट वर्ग– ट ठ ड (ड़) ढ (ढ़) ण [उत्क्षिप्त /द्विगुण/ताड़नजात/ विकसित/ द्विस्पृष्ट व्यंजन– (ड़ ढ़)
त वर्ग– त थ द ध न
प वर्ग– प फ ब भ म
अंतःस्थ– य र ल व
ऊष्म– श ष स ह (कुल 33 + (2) = 35)
संयुक्त व्यंजन– क्ष त्र ज्ञ श्र (कुल = 4)
(क् + ष = क्ष) (त् + र = त्र) (ज् + ञ = ज्ञ) (श् + र = श्र)

विदेशों से आगत/गृहीत ध्वनियाँ

अरबी-फारसी–हिंदी के सुशिक्षित वर्ग में प्रभावस्वरूप पाँच नए व्यंजन (क़, ख़, ग़, ज़, फ़) आ गए हैं, जिनमें ज़, फ़ का तो काफी प्रयोग होता है किन्तु क़, ख़, ग़, का प्रयोग वर्तमान में प्रायः कम ही होता है।

अंग्रेजी–हिंदी के सुशिक्षित वर्ग ने अपने उच्चारण में 'ऑ' को ग्रहण कर लिया है। सामान्य बोलचाल में अंग्रेजी ऑ से आ (फुटबाल), 'फ' से 'फ' (फोटो), तथा ज से ज (सेफ्टीरेजर) हो गया है ।

हिंदी भाषा में वर्णों के भेद

हिंदी भाषा में उच्चारण के दो प्रमुख तत्व हैं–(क) स्वर (ख) व्यंजन। 'वर्णों' की रचना में इन दोनों का योग रहता है।

हिंदी के स्वर वर्ण

स्वर उन **ध्वनियों** को कहते हैं जिनके उच्चारण में (मुँह में) वायुमार्ग में किसी भी प्रकार की **पूर्ण** या **अपूर्ण रुकावट** नहीं होती। परंपरागत पुस्तकों में हिंदी वर्णमाला में निम्नलिखित स्वरों का उल्लेख मिलता है–

ह्रस्व स्वर –अ, इ, उ, (ऋ)
दीर्घ स्वर –आ, ई, ऊ
संयुक्त स्वर– ए, ऐ, ओ, औ
अनुस्वार एवं विसर्ग – अं, अः
उच्चारण की दृष्टि से स्वरों की संख्या केवल दस है–
अ, आ, इ, ई, उ, ऊ, ए, ऐ, ओ, औ
'ऋ' उच्चारण के स्तर पर 'रि' अर्थात् व्यंजन (र) और स्वर (इ) का योग है। 'अं' अ तथा अनुस्वार (जो विभिन्न शब्दों में ङ् (गंगा), ञ् (चंचल), ण् (पंडित), न् (आनन्द), म् (पंप) का कार्य करता है) का मिला हुआ रूप है तथा अः ध्वनि अ + ह (जैसे प्रायः में) है। इस तरह शेष तीनों, अर्थात् ऋ, अं, अः स्वर न होकर स्वर-व्यंजन के मिले हुए रूप हैं।

इन दस में एक *ऑ* मिला कर स्वरों की संख्या **ग्यारह** मानी जा सकती है। यह अवश्य है कि *ऑ* का प्रयोग सभी नहीं करते। ह्रस्व ए, ह्रस्व ओ भी कुछ शब्दों में (बेंच, ओसारा) मिलते हैं।

अनुनासिक (ँ)–ऐसे स्वरों का उच्चारण *नाक* और *मुँह* से होता है और उच्चारण में लघुता रहती है। जैसे–गाँव, दाँत, आँगन आदि ।

अनुस्वार (ं)–यह *स्वर के पश्चात्* आने वाला *व्यंजन* है, जिसकी ध्वनि *नाक* से निकलती है। जैसै–अंगूर, कंकण आदि।

निरनुनासिक–केवल *मुँह* से बोले जाने वाला सस्वर वर्णों को *निरनुनासिक* कहते हैं। जैसे–इधर, उधर, आप, अपना, घर आदि।

विसर्ग (:) – *अनुस्वार* की तरह *विसर्ग* भी *स्वर* के बाद आता है। यह व्यंजन है और इसका उच्चारण *'ह'* के समान होता है। संस्कृत में इसका काफी प्रचलन है। हिंदी भाषा में अब इसका अभाव होता जा रहा है किन्तु आज भी तत्सम शब्दों में इसका प्रयोग किया जाता है। जैस–मनः कामना, पयःपान, अतः, दुःख आदि।

टिप्पणी–अनुस्वार और विसर्ग न तो *स्वर* हैं न *व्यंजन*; किन्तु ये स्वरों के सहारे चलते हैं। स्वर और व्यंजन दोनों में इनका प्रयोग किया जाता है। जैसे– अंगद, रंग। इस सन्दर्भ में आचार्य किशोरीदास वाजपेयी का कथन है कि "ये स्वर नहीं हैं और *व्यंजनों* की तरह ये *स्वरों* के पूर्व नहीं, *पश्चात्* आते हैं, "इसलिए *व्यंजन* नहीं। इसलिए इन दोनों ध्वनियों को '*अयोगवाह*' कहते हैं।" अयोगवाह का तात्पर्य है–*योग न होने पर भी जो साथ रहे*।

ध्यातव्य : पं. कामताप्रसाद गुरु के अनुसार, "व्यंजनों के अनेक प्रकार के उच्चारणों को स्पष्ट करने के लिए जब उनके साथ *स्वर का योग* होता है, तब स्वर का वास्तविक रूप जिस रूप में बदलता है, उसे *मात्रा* कहते हैं। मात्राएँ तीन हैं– **ह्रस्व, दीर्घ** और **प्लुत**। मात्राएँ *स्वरों की ही होती* हैं, *व्यंजन की नहीं*; क्योंकि व्यंजन बिना स्वर की सहायता के नहीं बोले जाते हैं। जब स्वर व्यंजन में लगते हैं, तब उनके दस प्रकार के रूप होते हैं–

ा, ि, ी, ु, ू, ृ, ॅ, े, ै, ो, ौ।

- स्वरों के व्यंजन में मिलने के इन रूपों को ही '**मात्रा**' कहते हैं क्योंकि मात्राएँ तो स्वरों की होती हैं। छन्दशास्त्र में 'ह्रस्व' मात्रा को '**लघु**' और 'दीर्घ' मात्रा को '*गुरु*' कहते हैं।

हिंदी में स्वरों का वर्गीकरण–

मात्रा एवं उच्चारण के आधार पर–मात्रा के आधार पर स्वर तीन प्रकार के होते हैं–(क) ह्रस्व स्वर (ख) दीर्घ स्वर (ग) प्लुत स्वर।

- जिनके उच्चारण में कम समय लगता है, उन्हें *ह्रस्व स्वर* (अ इ उ) कहते हैं।
- जिनके उच्चारण में ह्रस्व स्वर से अधिक समय लगता है, उन्हें *दीर्घ स्वर* (आ ई ऊ ए ऐ ओ औ आँ) कहते हैं।
- जिस स्वर के उच्चारण में तिगुना समय लगे, उसे '*प्लुत*' कहते हैं। इसका कोई चिह्न नहीं होता। इसके लिए तीन (३) का अंक लगाया जाता है। जैसे–ओ३म् । हिंदी भाषा में प्रायः *प्लुत का* प्रयोग नहीं होता। वैदिक भाषा में प्लुत *स्वर* का प्रयोग अधिक किया जाता था। इसे '*त्रिमात्रिक*' स्वर भी कहा जाता है।

स्वरों का वर्गीकरण उच्चारण के आधार पर

वर्ण नाम	उच्चारण स्थान	ह्रस्व स्वर	दीर्घ स्वर	निरानुनासिक मौखिक स्वर	अनुनासिक स्वर
कंठ्य	कंठ	अ	आ	अ, आ	अं, आँ
तालव्य	तालु (मुँह के भीतर की छत का पिछला भाग)	इ	ई	इ	ईँ
मूर्धन्य	मूर्धा (मुँह के भीतर की छत का अगला भाग) कंठ+तालु (कंठतालव्य) ओष्ठ+कंठ (कंठोष्ट्य)	ऋ – –	 ए, ऐ ओ, औ		
ओष्ठ्य	ओष्ठ/ओंठ	उ	ऊ		

हिंदी के व्यंजन वर्ण–

स्वर की सहायता से बोले जाने वाले वर्ण 'व्यंजन' कहलाते हैं। प्रत्येक व्यंजन के उच्चारण में 'अ' स्वर मिला होता है 'अ' के बिना व्यंजन का उच्चारण संभव नहीं। परंपरागत रूप से व्यंजनों की संख्या 33 मानी जाती है, किन्तु द्वि-गुण व्यंजन ड़ और ढ़ को जोड़ देने पर इनकी संख्या 35 हो जाती है। इनकी अग्रलिखित तीन श्रेणियाँ हैं–

- स्पर्श
- अन्तः स्थ
- ऊष्म

हिंदी में व्यंजनों का वर्गीकरण–

स्पर्श व्यंजन : ये कंठ, तालु, मूर्द्धा, दन्त और ओष्ठ के स्पर्श से बोले जाते हैं। यही कारण है कि इन्हें *स्पर्श व्यंजन* कहा जाता है। इनका अन्य नाम '*वर्गीय व्यंजन*' भी है क्योंकि ये उच्चारण–स्थान के अलग–अलग वर्गों में विभक्त हैं। स्पर्श व्यंजनों को *पाँच वर्गों* में विभक्त किया गया है। उदाहरणार्थ–

क वर्ग–क, ख, ग, घ, ङ (**कण्ठ से**)
च वर्ग–च, छ, ज, झ, ञ (**तालु से**)
ट वर्ग–ट, ठ, ड, ढ, ण (**मूर्द्धा से**)
त वर्ग–त, थ, द, ध, न (**दन्त से**)
प वर्ग–प, फ, ब, भ, म (**ओष्ठ से**)

अन्तःस्थ व्यंजन–इनका (य र ल व) उच्चारण जीभ, तालु, दाँत व ओठों के परस्पर सटाने से होता है, किन्तु कहीं भी पूर्ण स्पर्श नहीं होता है। अतः, ये चारों *अन्तःस्थ व्यंजन* '*अर्द्धस्वर*' कहलाते हैं।

वर्ग	उच्चारण स्थान
य – तालव्य वर्ग	तालु
र – वर्त्स्य वर्ग	दंतमूल/ मसूढ़ा
ल – वर्त्स्य वर्ग	दंतमूल/ मसूढ़ा
व– दंतोष्ठ्य वग	ऊपर के दांत + निचला ओष्ठ

ऊष्म व्यंजनों–इनका उच्चारण एक प्रकार की *रगड़* या *घर्षण* से उत्पन्न ऊष्म वायु से होता है। इनकी संख्या चार है– श, ष, स, ह।

वर्ग	उच्चारण स्थान
श– तालव्य वर्ग	तालु
ष– मूर्द्धा वर्ग	मूर्द्धा
स– वर्त्स्य वर्ग	दंतमूल/मसूढ़ा
ह– स्वर यंत्रीय	स्वरयंत्र (कंठ के भीतर स्थित)

संयुक्ताक्षर–हिंदी में 'क्ष (क् + ष), त्र (त् + र) ज्ञ (ज् + ञ) एवं श्र (श् + र) चार संयुक्त अक्षर हैं।

द्वित्व व्यंजन–

- जब दो समान व्यंजन एक साथ प्रयोग में लाए जाते हैं तो उसे द्वित्व व्यंजन कहते हैं। इसमें पहला व्यंजन 'स्वर रहित' और दूसरा व्यंजन 'स्वर सहित' होता है, जैसे–

  पक्का = प् + अ + क् + क् + आ

  कद्दू = क् + अ + द् + द् + ऊ

  [उपर्युक्त शब्दों में देखा जा सकता है कि क् + क् और द् + द् के मध्य कोई भी स्वर नहीं है।] अतः ये द्वित्व व्यंजन हैं।
- **हल :** जब व्यंजनों के नीचे एक **तिरछी रेखा** लगाई जाती है उसे **हल** कहते हैं। '**हल**' लगाने का तात्पर्य है कि व्यंजन में स्वरवर्ण का बिल्कुल अभाव है या फिर व्यंजन आधा है। जैसे–'क' व्यंजन वर्ण है, इसमें 'अ' स्वरवर्ण की ध्वनि छिपी है। यदि हम इस ध्वनि को अलग करना चाहें, तो 'क' में हलन्त या हल चिह्न लगाना जरूरी होगा। इस स्थिति में इसके रूप इस प्रकार होंगे – क्, ख्, ग्, च्।

व्यंजनों का वर्गीकरण : उच्चारण स्थान के आधार पर (एक परिप्रेक्ष्य)

वर्ण नाम	उच्चारण स्थान	अघोष अल्पप्राण	अघोष महाप्राण	घोष अल्पप्राण	घोष महाप्राण	घोष अल्पप्राण नासिक्य
कंठ्य	कंठ	क	ख	ग	घ	ङ
तालव्य	तालु (मुँह के भीतर की छत का पिछला भाग)	च	छ	ज ज़	झ	ञ
मूर्धन्य	मूर्धा (मुँह के भीतर की छत का अगला भाग)	ट	ठ	ड	ढ ढ़	ण
दंत्य	ऊपरी दाँतों के निकट से	त	थ	द	ध	न
ओष्ठ्य	दोनों ओठों से	प	फ	ब	भ	म
तालव्य	तालु (मुँह के भीतर की छत का अगला भाग)	-	श	य		
वर्त्स्य	दंत + मसूड़ा (दंत मूल से)	-	स	र, ल		
दंत्योष्ठ्य	ऊपर के दाँत + निचला ओंठ	-	फ़	व		
मूर्धन्य	मूर्धा (भीतर की छत का अगला भाग)	-	ष	-		
काकल्य/ स्वरयंत्रीय	स्वर यंत्र (कंठ के भीतर स्थित)	-	-	-	ह	
उत्क्षिप्त (मूर्धन्य)	जिनके उच्चारण में जीभ ऊपर उठकर झटके के साथ नीचे को आये।	-	-	ड़	ढ़	

महत्वपूर्ण अभ्यास प्रश्न

1. 'ग' वर्ण का उच्चारण स्थान है–
(A) तालाव्य (B) कंठ्य
(C) दंत्य (D) मूर्धन्य

2. 'ढ' वर्ण का उच्चारण स्थान है–
(A) मूर्धन्य (B) दन्त्य
(C) ओष्ठ्य (D) कंठ्य

3. प्रत्येक वर्ग का पहला और दूसरा वर्ण होता है :
(A) अघोष व्यंजन (B) सघोष व्यंजन
(C) द्वित्व व्यंजन (D) संयुक्त व्यंजन

4. अन्तःस्थ व्यंजन है :
(A) क ख ध झ (B) स ष श ह
(C) ण म न य (D) य र ल व

5. इनमें उष्म व्यंजन कौन है ?
(A) प् (B) व्
(C) य् (D) श्

6. इनमें से किस व्यंजन का उच्चारण तालु से होता है ?
(A) क् (B) च्
(C) द् (D) त्

7. 'ड' का उच्चारण स्थान है–
(A) मूर्द्धा (B) तालु
(C) ओष्ठ (D) दन्तोष्ठ

8. हिंदी में कुल कितने स्वर हैं ?
(A) 10 (B) 11
(C) 12 (D) 13

9. 'क्ष' वर्ण कौन-से संयुक्त व्यंजनों से मिलकर बना है ?
(A) क् + श् (B) ख् + ष्
(C) क् + स् (D) क् + ष्

10. 'ज्ञ' किन वर्णों का संयुक्त रूप है?
(A) ज् + अ (B) ज् + य
(C) ग् + अ (D) ग् + ञ

11. 'य, र, ल, व' कहलाते हैं–
(A) उष्म व्यंजन (B) स्पर्श व्यंजन
(C) अंतःस्थ व्यंजन (D) संयुक्त व्यंजन

12. 'योग न होने पर भी जो साथ रहे' उसे कहते हैं–
(A) विसर्ग (B) अनुनासिक
(C) निरनुनासिक (D) अयोगवाह

13. 'स्पर्श व्यंजन' की श्रेणी में आते हैं–
(A) क वर्ग (B) च वर्ग
(C) ट वर्ग (D) इनमें से सभी

14. वर्णमाला कहा जाता है–
(A) ऊष्म व्यंजन समूह को
(B) अंतस्थ व्यंजन समूह को
(C) वर्णों के क्रमबद्ध समूह को
(D) स्वरों के क्रमबद्ध समूह को

15. अयोगवाह कितने हैं ?
(A) तीन (B) दो
(C) चार (D) पाँच

16. अनुनासिक स्वरों का उच्चारण स्थल कौन-सा है?
(A) नाक और मुँह (B) नाक
(C) मुँह (D) ओष्ठ

17. मात्रा के आधार पर स्वर कितने प्रकार के होते हैं?
(A) 2 (B) 3
(C) 4 (D) 5

18. वर्णमाला में स्पर्श व्यंजनों की संख्या कितनी है?
(A) 25 (B) 30
(C) 20 (D) 35

19. निम्न में संयुक्त व्यंजन कौन-सा नहीं है ?
(A) त्र (B) य
(C) क्ष (D) ज्ञ

20. निम्नलिखित में से 'ऊष्म व्यंजन' कौन-से हैं?
(A) च–छ–ज (B) श–ष–स
(C) अ–ब–स (D) य–र–ल

उत्तरमाला

1. (B) **2.** (A) **3.** (A) **4.** (D) **5.** (D)
6. (B) **7.** (A) **8.** (B) **9.** (D) **10.** (A)
11. (C) **12.** (D) **13.** (D) **14.** (C) **15.** (B)
16. (A) **17.** (B) **18.** (A) **19.** (B) **20.** (B)

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