Science I
Class 10
Page No. 1

1. Gravitation

- Gravitation
- Kepler's laws
- Acceleration due to the gravitational force of the Earth
- Free fall
- Circular motion and centripetal force
- Newton's universal law of gravitation
- Escape velocity

Can you recall?

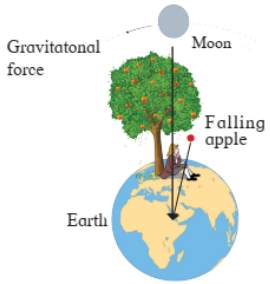
1. What are the effects of a force acting on an object?
2. What types of forces are you familiar with?
3. What do you know about the gravitational force?

We have seen in the previous standard that the gravitational force is a universal force and it acts not only between two objects on the earth but also between any two objects in the universe. Let us now learn how this force was discovered.

Gravitation

As we have learnt, the phenomenon of gravitation was discovered by Sir Isaac Newton. As the story goes, he discovered the force by seeing an apple fall from a tree on the ground. He wondered why all apples fall vertically downward and not at an angle to the vertical. Why do they not fly off in a horizontal direction?

After much thought, he came to the conclusion that the earth must be attracting the apple towards itself and this attractive force must be directed towards the center of the earth. The direction from the apple on the tree to the center of the earth is the vertical direction at the position of the apple and thus, the apple falls vertically downwards.



1.1 Concept of the gravitational force and the gravitational force between the earth and the moon.

Figure 1.1 on the left shows an apple tree on the earth. The force on an apple on the tree is towards the center of the earth i.e. along the perpendicular from the position of the apple to the surface of the earth. The Figure also shows the gravitational force between the earth and the moon. The distances in the figure are not according to scale.

Newton thought that if the force of gravitation acts on apples on the tree at different heights from the surface of the earth, can it also act on objects at even greater heights, much farther away from the earth, like for example, the moon? Can it act on even farther objects like the other planets and the Sun?

Use of ICT : Collect videos and ppts about the gravitational force of different planets.

Force and Motion

We have seen that a force is necessary to change the speed as well as the direction of motion of an object.

Can you recall? What are Newton's laws of motion?

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Science I
Class 10
Page No. 2

Introduction to scientist

Great Scientists: Sir Issac Newton (1642-1727) was one of the greatest scientists of recent times. He was born in England. He gave his laws of motion, equations of motion and theory of gravity in his book Principia. Before this book was written, Kepler had given three laws describing planetary motions. However, the reason why planets move in the way described by Kepler's laws was not known. Newton, with his theory of gravity, mathematically derived Kepler's laws.

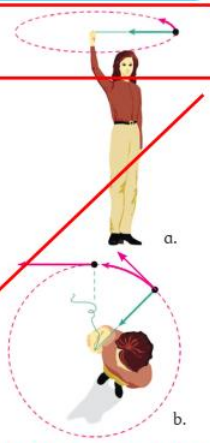
In addition to this, Newton did ground breaking work in several areas including light, heat, sound and mathematics. He invented a new branch of mathematics. This is called calculus and has wide ranging applications in physics and mathematics. He was the first scientist to construct a reflecting telescope.

Circular motion and Centripetal force

Try this

Tie a stone to one end of a string. Take the other end in your hand and rotate the string so that the stone moves along a circle as shown in figure 1.2 a. Are you applying any force on the stone? In which direction is this force acting? How will you stop this force from acting? What will be the effect on the stone?

As long as we are holding the string, we are pulling the stone towards us i.e. towards the centre of the circle and are applying a force towards it. The force stops acting if we release the string. In this case, the stone will fly off along a straight line which is the tangent to the circle at the position of the stone when the string is released, because that is the direction of its velocity at that instant of time (Figure 1.2 b). You may recall that we have performed a similar activity previously in which a 5 rupee coin kept on a rotating circular disk flies off the disk along the tangent to the disk.Thus, a force acts on any object moving along a circle and it is directed towards the centre of the circle. This is called the **Centripetal force.** 'Centripetal' means centre seeking, i.e. the object tries to go towards the centre of the circle because of this force.



1.2 A stone tied to a string, moving along a circular path and its velocity in tangential direction

You know that the moon, which is the natural satellite of the earth, goes round it in a definite orbit. The direction of motion of the moon as well as its speed constantly changes during this motion. Do you think some force is constantly acting on the moon? What must be the direction of this force? How would its motion have been if no such force acted on it? Do the other planets in the solar system revolve around the Sun in a similar fashion? Is similar force acting on them? What must be its direction?

From the above activity, example and questions it is clear that for the moon to go around the earth, there must be a force which is exerted on the moon and this force must be exerted by the earth which attracts the moon towards itself. Similarly, the Sun must be attracting the planets, including the earth, towards itself.

Science I
Class 10
Page No. 4

Use your brain power If the area ESF in figure 1.4 is equal to area ASB, what will you infer about EF?

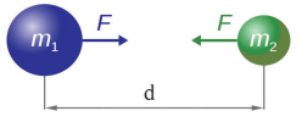
Newton's universal law of gravitation

All the above considerations including Kepler's laws led Newton to formulate his theory of Universal gravity. According to this theory, every object in the Universe attracts every other object with a definite force. This force is directly proportional to the product of the masses of the two objects and is inversely proportional to the square of the distance between them.

An introduction to scientists

Johannes Kepler (1571-1630) was a German astronomer and mathematician. He started working as a helper to the famous astronomer Tycho Brahe in Prague in 1600. After the sudden death of Brahe in 1601, Kepler was appointed as the Royal mathematician in his place. Kepler used the observations of planetary positions made by Brahe to discover the laws of planetary motion. He wrote several books. His work was later used by Newton in postulating his law of gravitation.

Figure 1.5 shows two objects with masses m_1 and m_2 kept at a distance d from each other. Mathematically, the gravitational force of attraction between these two bodies can be written as



1.5 Gravitational force between two objects

$$F \propto \frac{m_1 m_2}{d^2} \quad \text{or} \quad F = G\frac{m_1 m_2}{d^2} \quad \ldots\ldots (2)$$

Here, G is the constant of proportionality and is called the Universal gravitational constant.

The above law means that if the mass of one object is doubled, the force between the two objects also doubles. Also, if the distance is doubled, the force decreases by a factor of 4. If the two bodies are spherical, the direction of the force is always along the line joining the centres of the two bodies and the distance between the centres is taken to be d. In case when the bodies are not spherical or have irregular shape, then the direction of force is along the line joining their centres of mass and d is taken to be the distance between the two centres of mass.

From equation (2), it can be seen that the value of G is the gravitational force acting between two unit masses kept at a unit distance away from each other. Thus, in SI units, the value of G is equal to the gravitational force between two masses of 1 kg kept 1 m apart.

Use your brain power

Show that in SI units, the unit of G is Newton $m^2\ kg^{-2}$. The value of G was first experimentally measured by Henry Cavendish. In SI units its value is $6.673 \times 10^{-11}\ N\ m^2\ kg^{-2}$.

ELITE Tutors

Science I
Class 10
Page No. 5

The centre of mass of an object is the point inside or outside the object at which the total mass of the object can be assumed to be concentrated. The centre of mass of a spherical object having uniform density is at its geometrical centre. The centre of mass of any object having uniform density is at its centroid.

Why did Newton assume inverse square dependence on distance in his law of gravitation? He was helped by Kepler's third law in this as shown below.

Uniform circular motion / Magnitude of centripetal force

Consider an object moving in a circle with constant speed. We have seen earlier that such a motion is possible only when the object is constantly acted upon by a force directed towards the centre of the circle. This force is called the centripetal force. If m is the mass of the object, v is its speed and r is the radius of the circle, then it can be shown that this force is equal to $F = m v^2/r$.

If a planet is revolving around the Sun in a circular orbit in uniform circular motion, then the centripetal force acting on the planet towards the Sun must be $F = mv^2/r$, where, m is the mass of the planet, v is its speed and r is its distance from the Sun.

$$\text{Speed} = \frac{\text{distance travelled}}{\text{time taken}}$$

The speed of the planet can be expressed in terms of the period of revolution T as follows.

The distance travelled by the planet in one revolution =perimeter of the orbit $2\pi r$; r = distance of the planet from the Sun, Time taken = Period of revolution = T

$$v = \frac{\text{distance travelled}}{\text{time taken}} = \frac{2\pi r}{T}$$

$$F = \frac{mv^2}{r} = \frac{m\left(\frac{2\pi r}{T}\right)^2}{r} = \frac{4m\pi^2 r}{T^2}$$, multiplying and dividing by r^2 we get,

$$F = \frac{4m\pi^2}{r^2} = \left(\frac{r^3}{T^2}\right)$$. According to Kepler's third law, $\frac{T^2}{r^3} = K$

$$F = \frac{4m\pi^2}{r^2 K}$$, But $\frac{4m\pi^2}{K}$ = Constant

Thus, Newton concluded that the centripetal force which is the force acting on the planet and is responsible for its circular motion, must be inversely proportional to the square of the distance between the planet and the Sun. Newton identified this force with the force of gravity and hence postulated the inverse square law of gravitation. The gravitational force is much weaker than other forces in nature but it controls the Universe and decides its future. This is possible because of the huge masses of planets, stars and other constituents of the Universe.

Use your brain power

Is there a gravitational force between two objects kept on a table or between you and your friend sitting next to you? If yes, why don't the two move towards each other?

Science I
Class 10
Page No. 6

Solved examples

Example 1 : Mahendra and Virat are sitting at a distance of 1 metre from each other. Their masses are 75 kg and 80 kg respectively. What is the gravitational force between them?

Given : r = 1 m, m_1 = 75 kg, m_2 = 80 kg and G = 6.67 x 10^{-11} Nm^2/kg^2

According to Newton's law

$$F = \frac{G m_1 m_2}{r^2}$$

$$F = \frac{6.67 \times 10^{-11} \times 75 \times 80}{1^2} N$$

$$= 4.002 \times 10^{-7} N$$

The gravitational force between Mahendra and Virat is 4.002 x 10^{-7} N

This is a very small force. If the force of friction between Mahendra and the bench on which he is sitting is zero, then he will start moving towards Virat under the action of this force. We can calculate his acceleration and velocity by using Newton's laws of motion.

Example 2 : In the above example, assuming that the bench on which Mahendra is sitting is frictionless, starting with zero velocity, what will be Mahendra's velocity of motion towards Virat after 1 s ? Will this velocity change with time and how?

Given: Force on Mahendra = F = 4.002 x 10^{-7} N, Mahendra's mass = m = 75 kg

According to Newton's second law, the acceleration produced by the force on Mahendra = m = 75 kg.

$$a = \frac{F}{m} = \frac{4.002 \times 10^{-7}}{75} = 5.34 \times 10^{-9} \ m/s^2$$

Using Newton's first equation, we can calculate Mahendra's velocity after 1s, Newton's first equation of motion is

v = u + a t;

As Mahendra is sitting on the bench, his initial velocity is zero (u=0)

Assuming the bench to be frictionless,

v = 0 + 5.34 x 10^{-9} x 1 m/s

= 5.34 x 10^{-9} m/s

Mahendra's velocity after 1 s will be 5.34 x 10^{-9} m/s .

This is an extremely small velocity. The velocity will increase with time because of the acceleration. The acceleration will also not remain constant because as Mahendra moves towards Virat, the distance between them will decrease, causing an increase in the gravitational force, thereby increasing the acceleration as per Newton's second law of motion.

Use your brain power !

Assuming the acceleration in Example 2 above remains constant, how long will Mahendra take to move 1 cm towards Virat?

Do you know ?

You must be knowing about the high and low tides that occur regularly in the sea. The level of sea water at any given location along sea shore increases and decreases twice a day at regular intervals. High and low tides occur at different times at different places. The level of water in the sea changes because of the gravitational force exerted by the moon. Water directly under the moon gets pulled towards the moon and the level of water there goes up causing high tide at that place. At two places on the earth at 90° from the place of high tide, the level of water is minimum and low tides occur there as shown in figure 1.6

1.6 Low and high tides

ELITE Tutors

Science I
Class 10
Page No. 7

~~Collect information about high and low tides from geography books. Observe the timing of high and low tides at one place when you go for a picnic to be a beach. Take pictures and hold an exhibition.~~

Earth' gravitational force

Will the velocity of a stone thrown vertically upwards remain constant or will it change with time? How will it change? Why doesn't the stone move up all the time? Why does it fall down after reaching a certain height? What does its maximum height depend on ?

The earth attracts every object near it towards itself because of the gravitational force. The centre of mass of the earth is situated at its centre, so the gravitational force on any object due to the earth is always directed towards the centre of the earth. Because of this force, an object falls vertically downwards on the earth.

Similarly, when we throw a stone vertically upwards, this force tries to pull it down and reduces its velocity. Due to this constant downward pull, the velocity becomes zero after a while. The pull continues to be exerted and the stone starts moving vertically downward towards the centre of the earth under its influence.

Solved Examples

Example 1: Calculate the gravitational force due to the earth on Mahendra in the earlier example.

Given: Mass of the earth = $m_1 = 6 \times 10^{24}$ kg
Radius of the earth = $R = 6.4 \times 10^6$ m
Mahendra's mass = $m_2 = 75$ kg
$G = 6.67 \times 10^{-11}$ Nm^2/kg^2

Using the force law, the gravitational force on Mahendra due to earth is given by

This force is 1.83×10^9 times larger than the gravitational force between Mahendra and Virat.

$$F = \frac{G m_1 m_2}{R^2}$$

$$F = \frac{6.67 \times 10^{-11} \times 75 \times 6 \times 10^{24}}{(6.4 \times 10^6)^2} N = 733 N$$

Example 2: Starting from rest, what will be Mahendra's velocity after one second if he is falling down due to the gravitational force of the earth?

Given: u = 0, F = 733 N,
Mahendra's mass = m = 75 kg
time t = 1 s
Mahendra's acceleration

$$a = \frac{F}{m} = \frac{733}{75} \ m/s^2$$

According to Newton's first equation of motion,
$v = u + a t$
Mahendra's velocity after 1 second
$v = 0 + 9.77 \times 1$ m/s
$v = 9.77$ m/s
This is 1.83×10^9 times Mahendra's velocity in example 2, on page 6.

Use your brain power !

According to Newton's law of gravitation, every object attracts every other object.

Thus, if the earth attracts an apple towards itself, the apple also attracts the earth towards itself with the same force. Why then does the apple fall towards the earth, but the earth does not move towards the apple?

The gravitational force due to the earth also acts on the moon beacause of which it revolves around the earth. Similar situation exists for the artificial satellites orbiting the earth. The moon and the artificial satellites orbit the earth. The earth attracts them towards itself but unlike the falling apple, they do not fall on the earth, why? This is beacause of the velocity of the moon and the satellites along their orbits. If this velocity was not there, they would have fallen on the earth.

Science I
Class 10
Page No. 9

Place	Height (km)	g (m/s²)
Surface of the earth (average)	0	9.8
Mount Everest	8.8	9.8
Maximum height reached by man-made balloon	36.6	9.77
Height of a typical weather satellite	400	8.7
Height of communication satellite	35700	0.225

1.7 Table showing change of g with height above the earth's surface

C. Change with depth : The value of g also changes if we go inside the earth. The value of r in equation (5) decreases and one would think that the value of g should increase as per the formula. However, the part of the earth which contributes towards the gravitational force felt by the object also decreases. Which means that the value of M to be used in equation (5) also decreases. As a combined result of change in r and M, the value of g decreases as we go deep inside the earth.

Think about it

1. Will the direction of the gravitational force change as we go inside the earth?
2. What will be the value of g at the centre of the earth?

Every planet and satellite has different mass and radius. Hence, according to equation (6), the values of g on their surfaces are different. On the moon it is about 1/6th of the value on the earth. As a result, using the same amount of force, we can jump 6 times higher on the moon as compared to that on the earth.

~~**Mass and Weight**~~

~~**Mass :** Mass is the amount of matter present in the object. The SI unit of mass is kg. Mass is a scalar quantity. Its value is same everywhere. Its value does not change even when we go to another planet. According to Newton's first law, it is the measure of the inertia of an object. Higher the mass, higher is the inertia.~~

~~**Weight :** The weight of an object is defined as the force with which the earth attracts the object.~~ The force (F) on an object of mass m on the surface of the earth can be written using equation (4)

$$\therefore \text{Weight, } W = F = m\,g \quad .... \quad \left(g = \frac{G\,M}{R^2} \right)$$

Weight being a force, its SI unit is Newton. Also, the weight, being a force, is a vector quantity and its direction is towards the centre of the earth. As the value of g is not same everywhere, the weight of an object changes from place to place, though its mass is constant everywhere.

~~Colloquially we use weight for both mass and weight and measure the weight in kilograms which is the unit of mass. But in scientific language when we say that Rajeev's weight is 75 kg, we are talking about Rajeev's mass. What we mean is that Rajeev's weight is equal to the gravitational force on 75 kg mass. As Rajeev's mass is 75 kg, his weight on earth is F = mg = 75 x 9.8 = 735 N. The weight of 1 kg mass is 1 x 9.8 = 9.8 N. Our weighing machines tell us the mass. The two scale balances in shops compare two weights i.e. two masses.~~

Science I
Class 10
Page No. 10

Use your brain power !

1. Will your weight remain constant as you go above the surface of the earth?
2. Suppose you are standing on a tall ladder. If your distance from the centre of the earth is 2R, what will be your weight?

Solved Examples

Example 1: If a person weighs 750 N on earth, how much would be his weight on the Moon given that moon's mass is $\frac{1}{81}$ of that of the earth and its radius is $\frac{1}{3.7}$ of that of the earth ?

Given: Weight on earth = 750 N,

Ratio of mass of the earth (M_E) to mass of the moon (M_M) = $\frac{M_E}{M_M} = 81$

Ratio of radius of earth (R_E) to radius of moon (R_M) = $\frac{R_E}{R_M} = 3.7$

Let the mass of the person be m kg

Weight on the earth = m g = $750 = \frac{m G M_E}{R_E^2}$ $\quad \therefore m = \frac{750 R_E^2}{(G M_E)}$ ..... (i)

Weight on Moon $= \frac{m G M_M}{R_M^2}$ using (i)

$= \frac{750 R_E^2}{(G M_E)} \times \frac{G M_M}{R_M^2} = 750 \frac{R_E^2}{R_M^2} \times \frac{M_M}{M_E} = 750 \times (3.7)^2 \times \frac{1}{81} = 126.8$ N

The weight on the moon is nearly 1/6th of the weight on the earth. We can write the weight on moon as mg_m (g_m is the accelaration due to gravity on the moon). Thus g_m is 1/6th of the g on the earth.

Do you know ?

Gravitational waves

Waves are created on the surface of water when we drop a stone into it. Similarly you must have seen the waves generated on a string when both its ends are held in hand and it is shaken. Light is also a type of wave called the electromagnetic wave. Gamma rays, X-rays, ultraviolet rays, infrared rays, microwave and radio waves are all different types of electromagnetic waves. Astronomical objects emit these waves and we receive them using our instruments. All our knowledge about the universe has been obtained through these waves.

Gravitational waves are a very different type of waves. They have been called the waves on the fabric of space-time. Einsteine predicted their existence in 1916. These waves are very weak and it is very difficult to detect them. Scientists have constructed extremely sensitive instruments to detect the gravitational waves emitted by astronomical sources. Among these, LIGO (Laser Interferometric Gravitational Wave Observatory) is the prominent one. Exactly after hundred years of their prediction, scientists detected these waves coming from an astronomical source. Indian scientists have contributed significantly in this discovery. This discovery has opened a new path to obtain information about the Universe.

Science I
Class 10
Page No. 11

Free fall

Try this

Take a small stone. Hold it in your hand. Which forces are acting on the stone? Now release the stone. What do you observe? What are the forces acting on the stone after you release it?

We know that the force of gravity due to the earth acts on each and every object. When we were holding the stone in our hand, the stone was experiencing this force, but it was balanced by a force that we were applying on it in the opposite direction. As a result, the stone remained at rest. Once we release the stone from our hands, the only force that acts on it is the gravitational force of the earth and the stone falls down under its influence. Whenever an object moves under the influence of the force of gravity alone, it is said to be falling freely. Thus the released stone is in a free fall. In free fall, the initial velocity of the object is zero and goes on increasing due to the acceleration due to gravity of the earth. During free fall, the frictional force due to air opposes the motion of the object and a buoyant force also acts on the object. Thus, true free fall is possible only in vacuum.

For a freely falling object, the velocity on reaching the earth and the time taken for it can be calculated by using Newton's equations of motion. For free fall, the initial velocity $u = 0$ and the acceleration $a = g$. Thus we can write the equations as

$$v = g\,t$$

$$s = \frac{1}{2} g\,t^2$$

$$v^2 = 2\,g\,s$$

For calculating the motion of an object thrown upwards, acceleration is negative, i.e. in a direction opposite to the velocity and is taken to be $-g$. The magnitude of g is the same but the velocity of the object decreases because of this -ve acceleration.

The moon and the artificial satellites are moving only under the influence of the gravitational field of the earth. Thus they are in free fall.

Do you know ?

The value of g is the same for all objects at a given place on the earth. Thus, any two objects, irrespective of their masses or any other properties, when dropped from the same height and falling freely will reach the earth at the same time. Galileo is said to have performed an experiment around 1590 in the Italian city of Pisa. He dropped two spheres of different masses from the leaning tower of Pisa to demonstrate that both spheres reached the ground at the same time.

When we drop a feather and a heavy stone at the same time from a height, they do not reach the earth at the same time. The feather experiences a buoyant force and a frictional force due tov air and therefore floats and reaches the ground slowly, later than the heavy stone. The buoyant and frictional forces on the stone are much less than the weight of the stone and does not affect the speed of the stone much. Recently, scientists performed this experiment in vacuum and showed that the feather and stone indeed reach the earth at the same time.

https://www.youtube.com/watch?v=eRNC5kcvINA

Science I
Class 10
Page No. 14

From the priciple of conservation of energy

$E_1 = E_2$

$$\frac{1}{2} mv^2_{esc} - \frac{GMm}{R} = 0$$

$$v^2_{esc} = \frac{2\,GM}{R}$$

$$v_{esc} = \sqrt{\frac{2\,GM}{R}}$$

$$= \sqrt{2\,g\,R}$$

$$= \sqrt{(2 \times 9.8 \times 6.4 \times 10^6)} = 11.2 \text{ km/s}$$

The spacecrafts which are sent to the moon or other planets have to have their initial velocity larger than the escape velocity so that they can overcome earth's gravitational attraction and can travel to these objects.

Solved Examples

Example 1. Calculate the escape velocity on the surface of the moon given the mass and radius of the moon to be 7.34×10^{22} kg and 1.74×10^6 m respectively.

Given: $G = 6.67 \times 10^{-11}$ N m^2/kg^2, mass of the moon = $M = 7.34 \times 10^{22}$ kg and radius of the moon = $R = 1.74 \times 10^6$ m.

Escape velocit y = $v_{esc} = \sqrt{\frac{2\,GM}{R}}$

$$\sqrt{\frac{2 \times 6.67 \times 10^{-11} \times 7.34 \times 10^{22}}{1.74 \times 10^6}}$$

= 2.37 km/s

Escape velocity on the moon 2.37 km/s.

Do you know ?

Weightlessness in space

Space travellers as well as objects in the spacecraft appear to be floating. Why does this happen? Though the spacecraft is at a height from the surface of the earth, the value of g there is not zero. In the space station the value of g is only 11% less than its value on the surface of the earth. Thus, the height of a spacecraft is not the reason for their weightlessness. Their weightlessness is caused by their being in the state of free fall. Though the spacecraft is not falling on the earth because of its velocity along the orbit, the only force acting on it is the gravitational force of the earth and therefore it is in a free fall. As the velocity of free fall does not depend on the properties of an object, the velocity of free fall is the same for the spacecraft, the travelers and the objects in the craft. Thus, if a traveller releases an object from her hand, it will remain stationary with respect to her and will appear to be weightless.

Exercise

1. Study the entries in the following table and rewrite them putting the connected items in a single row.

I	II	III
Mass	m/s^2	Zero at the centre
Weight	kg	Measure of inertia
Accelera-tion due to gravity	Nm^2/kg^2	Same in the entire universe
Gravita-tional con-stant	N	Depends on height

2. Answer the following questions.

a. What is the difference between mass and weight of an object. Will the mass and weight of an object on the earth be same as their values on Mars? Why?

b What are (i) free fall, (ii) acceleration due to gravity (iii) escape velocity (iv) centripetal force ?

c. Write the three laws given by Kepler. How did they help Newton to arrive at the inverse square law of gravity?

Science I
Class 10
Page No.16

2.Periodic Classification of Elements

- Elements and their classification
- Newlands Law of Octaves
- Modern Periodic Table
- Dobereiner's Triads
- Mendeleev's Periodic Table

Can you recall?

1. What are the types of matter?
2. What are the types of elements?
3. What are the smallest particles of matter called?
4. What is the difference between the molecules of elements and compounds?

Classification of elements

We have learnt in the previous standards that all the atoms of an element are of only one type. Today 118 elements are known to the scientific world. However, around year 1800 only about 30 elements were known. More number of elements were discovered in the course of time. More and more information about the properties of these elements was gathered. To ease the study of such a large number of elements, scientists started studying the pattern if any, in the vast information about them. You know that in the initial classification elements were classified into the groups of metals and nonmetals. Later on another class of elements called metalloids was noticed. As the knowledge about elements and their properties went on increasing different scientists started trying out different methods of classification.

Dobereiner's Triads

In the year 1817 a German scientist Dobereiner suggested that properties of elements are related to their atomic masses. He made groups of three elements each, having similar chemical properties and called them triads. He arranged the three elements in a triad in an increasing order of atomic mass and showed that the atomic mass of the middle element was approximately equal to the mean of the atomic masses of the other two elements. However, all the known elements could not be classified into the Dobereiner's triads.

Sr. No.	Triad	Element -1 Actual atomic mass(a)	Element - 2 Mean = $\frac{a+c}{2}$	Element - 2 Actual atomic mass	Element - 3 Actual atomic mass (c)
1	Li, Na, K	Lithium (Li) 6.9	Sodium $\frac{6.9+39.1}{2}=23.0$	(Na) 23.0	Potassium (K) 39.1
2	Ca, Sr, Ba	Calcium (Ca) 40.1	Strontium $\frac{40.1+137.3}{2}=88.7$	(Sr) 87.6	Barium (Ba) 137.3
3	Cl, Br, I	Chlorine (Cl) 35.5	Bromine $\frac{35.5+126.9}{2}=81.2$	(Br) 79.9	Iodine (I) 126.9

2.1 Dobereiner's Triads

Can you tell?

Identify Dobereiner's triads from the following groups of elements having similar chemical properties.

1. Mg (24.3), Ca (40.1), Sr (87.6)
2. S (32.1), Se (79.0), Te (127.6)
3. Be (9.0), Mg (24.3), Ca (40.1)

Science I
Class 10
Page No. 17

Newlands' Law of Octaves

The English scientist John Newlands correlated the atomic masses of elements to their properties in a diffrent way. In the year 1866 Newlands arranged the elements known at that time in an increasing order of their atomic masses. It started with the lightest element hydrogen and ended up with thorium. He found that every eighth element had properties similar to those of the first. For example, sodium is the eighth element from lithium and both have similar properties. Also, magnesium shows similarity to beryllium and chlorine shows similarity with fluorine. Newlands compared this similarity with the octaves in music. He called the similarity observed in the eighth and the first element as the **Law of octaves.**

Do you know ?

In the Indian music system there are seven main notes, namely, Sa, Re, Ga, Ma, Pa, Dha, Ni, and their collection is called 'Saptak'. The frequency of the notes goes on increasing from 'Sa' to 'Ni'. Then comes, the 'Sa' of the upper 'Saptak' at the double the frequency of the original 'Sa'. It means that notes repeat after completion of one 'Saptak'. The seven notes in the western music are Do, Re, Mi, Fa, So, La, Ti.

The note 'Do' having double the original frequency comes again at the eighth place. This is the octave of western notes. Music is created by the variety in the use of these notes.

Musical Note	Do (Sa)	Re (Re)	Mi (Ga)	Fa (Ma)	Sol (Pa)	La (Dha)	Ti (Ni)
Elements	H	Li	Be	B	C	N	O
	F	Na	Mg	Al	Si	P	S
	Cl	K	Ca	Cr	Ti	Mn	Fe
	Co &Ni	Cu	Zn	Y	In	As	Se
	Br	Rb	Sr	Ce & La	Zr		

2.2 Newlands' Octaves

Many limitation were found in Newlands' octaves. This law was found to be applicable only upto calcium. Newlands fitted all the known elements in a table of 7 X 8 that is 56 boxes. Newlands placed two elements each in some boxes to accommodate all the known elements in the table. For example, Co and Ni, Ce and La. Moreover, he placed some elements with different properties under the same note in the octave. For example, Newlands placed the metals Co and Ni under the note 'Do' along with halogens, while Fe, having similarity with Co and Ni, away from them along with the nonmetals O and S under the note 'Ti'. Also, Newlands' octaves did not have provision to accommodate the newly discovered elements. The properties of the new elements discovered later on did not fit in the Newlands' law of octaves.

Mendeleev's Periodic table

The Russian scientist Dmitri Mendeleev developed the periodic table of elements during the period 1869 to 1872 A.D. Mendeleev's periodic table is the most important step in the classification of elements. Mendeleev considered the fundamental property of elements, namely, the atomic mass, as standard and arranged 63 elements known at that time in an increasing order of their atomic masses. Then he transformed this into the periodic table of elements in accordance with the physical and chemical properties of these elements.

Science I
Class 10
Page No. 18

Mendeleev organized the periodic table on the basis of the chemical and physical properties of the elements. These were the molecular formulae of hydrides and oxides of the elements, melting points, boiling points and densities of the elements and their hydrides and oxides. Mendeleev found that the elements with similar physical and chemical properties repeat after a definite interval. **On the basis of this finding Mendeleev stated the following periodic law.**

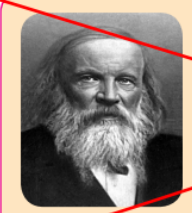
Properties of elements are periodic function of their atomic masses.

The vertical columns in the Mendeleev's periodic table are called groups while the horizontal rows are called periods.

Series ↓	Group I - R^2O	Group II - RO	Group III - R^2O^3	Group IV RH^4 RO^2	Group V RH^3 R^2O^5	Group VI RH^2 RO^3	Group VII RH R^2O^7	Group VIII - RO^4
1	H=1							
2	Li=7	Be=9.4	B=11	C=12	N=14	O=16	F=19	
3	Na=23	Mg=24	Al=27.3	Si=28	P=31	S=32	Cl= 35.5	
4	K=39	Ca=40	- = 44	Ti= 48	V=51	Cr= 52	Mn=55	Fe=56, Co=59 Ni=59, Cu=63
5	(Cu=63)	Zn=65	-=68	-=72	As=75	Se=78	Br=80	
6	Rb=85	Sr=87	?Yt=88	Zr=90	Nb=94	Mo=96	-=100	Ru=104,Rh=104 Pd=106,Ag=108
7	(Ag=108)	Cd=112	In=113	Sn=118	Sb=122	Te=125	J=127	
8	Cs=133	Ba=137	?Di=138	?Ce=140	-	-	-	----
9	(-)	-	-	-	-	-	-	
10	-	-	?Er=178	?La=180	Ta=182	W=184	-	Os=195, Ir=197 Pt=198, Au=199
11	(Au=199)	Hg=200	Ti=204	Pb=207	Bi= 208	-	-	
12	-	-	-	Th=231	-	U=240	-	---

2.3 Mendeleev's Periodic Table

(The general molecular formulae of compounds shown as R^2O, R^2O^3, etc, in the upper part of Mendeleev's periodic table, are written as R_2O, R_2O_3,etc. in the present system.)



Dmitri Mendeleev

Introduction to scientist

Dmitri Mendeleev (1834-1907) was a professor in the St. Petersburg University. He made separate card for every known element showing its atomic mass. He arranged the cards in accordance with the atomic masses and properties of the elements which resulted in the invention of the periodic table of elements.

Science I
Class 10
Page No. 19

Think about it

1. There are some vacant places in the Mendeleev's periodic table. In some of these places the atomic masses are seen to be predicted. Enlist three of these predicted atomic masses along with their group and period.
2. Due to uncertainty in the names of some of the elements, a question mark is indicated before the symbol in the Mendeleev's periodic table. What are such symbols?

Merits of Mendeleev's periodic table

Science is progressive. There is a freedom in science to revise the old inference by using more advanced means and methods of doing experiments. These characteristics of science are clearly seen in the Mendeleev's periodic table.

While applying the law that the properties of elements are a periodic function of their atomic masses, to all the known elements, Mendeleev arranged the elements with a thought that the information available till then was not final but it could change. As a result of this, Mendeleev's periodic table demonstrates the following merits.

1. Atomic masses of some elements were revised so as to give them proper place in the periodic table in accordance with their properties. For example, the previously determined atomic mass of beryllium, 14.09, was changed to the correct value 9.4, and beryllium was placed before boron.
2. Mendeleev kept vacant places in the periodic table for elements not discovered till then. Three of these unknown elements were given the names eka-boron, eka-aluminium and eka-silicon from the known neighbours and their atomic masses were indicated as 44, 68 and 72, respectively. Not only this but their properties were also predicted. Later on these elements were discovered and named as scandium (Sc), gallium (Ga) and germanium (Ge) respectively. The properties of these elements matched well with those predicted by Mendeleev. See table 2.4. Due to this success all were convinced about the importance of Mendeleev's periodic table and this method of classification of elements was accepted immediately.

Property	Eka- aluminium(E) (Mendeleev's prediction)	Gallium (Ga)(actual)
1. Atomic mass	68	69.7
2. Density (g/cm^3)	5.9	5.94
3. Melting point(°C)	Low	30.2
4. Formula of chloride	ECl_3	$GaCl_3$
5. Formula of oxide	E_2O_3	Ga_2O_3
6. Nature of oxide	Amphoteric oxide	Amphoteric oxide

2.4 Actual and predicted properties of gallium.

3. There was no place reserved for noble gases in Mendeleev's original periodic table. However, when noble gases such as helium, neon and argon were discovered towards the end of nineteenth century, Mendeleev created the ' zero' group without disturbing the original periodic table in which the noble gases were fitted very well.

Use your brain power !

Chlorine has two isotopes,viz, C1-35 and C1-37. Their atomic masses are 35 and 37 respectively. Their chemical properties are same. Where should these be placed in Mendeleev's periodic table? In different places or in the same place?

Science I
Class 10
Page No. 21

Modern periodic table : long form of the periodic table

The classifiacation of elements resulting from an arrangement of the elements in an increasing order of their atomic numbers is the modern periodic table. The properties of elements can be predicted more accurately with the help of the modern periodic table formed on the basis of atomic numbers. The modern periodic table is also called the long form of the periodic table.

In the modern periodic table the elements are arranged in accordance with their atomic number. (see table 2.7) As a result, most of the drawbacks of Mendeleev's periodic table appear to be removed. However, the ambiguity about the position of hydrogen is not removed even in the modern periodic table.

We have seen in the previous standard that the electronic configuration of an atom, the way in which the electron are distributed in the shells around the nucleus, is determined by the total number of electrons in it; and the total number of electrons in an atom is same as the atomic number. The relation between the atomic number of an element and its electronic configuration is clearly seen in the modern periodic table.

Use your brain power !

Position of the elements in the periodic elements.....

1. How is the problem regarding the position of cobalt (^{59}Co) and nickel (^{59}Ni) in Mendeleev's periodic table resolved in modern periodic table?
2. How did the position of $^{35}_{17}Cl$ and $^{37}_{17}Cl$ get fixed in the modern periodic table?
3. Can there be an element with atomic mass 53 or 54 in between the two elements, chromium $^{52}_{24}Cr$ and manganese $^{55}_{25}Mn$?
4. What do you think? Should hydrogen be placed in the group 17 of halogens or group 1 of alkali metals in the modern periodic table?

Structure of the Modern Periodic Table

The modern periodic table contains seven horizontal rows called the periods 1 to 7. Similarly, the eighteen vertical columns in this table are the groups 1 to 18. The arrangement of the periods and groups results into formation of boxes. Atomic numbers are serially indicated in the upper part of these boxes. Each box corresponds to the place for one element.

Apart from these seven rows, two rows are shown separately at the bottom of the periodic table. These are called lanthanide series and actinide series, respectively. There are 118 boxes in the periodic table including the two series. It means that there are 118 places for elements in the modern periodic table. Very recently formation of a few elements was established experimentally and thereby the modern periodic table is now completely filled. All the 118 elements are now discovered.

The entire periodic table is divided into four blocks,viz, s-block, p-block, d-block and f-block. The s-block contains the groups 1 and 2. The groups 13 to 18 constitute the p-block. The groups 3 to 12 constitute the d-block, while the lanthanide and actinide series at the bottom form the f-block. The d-block elements are called transition elements. A zig-zag line can be drawn in the p-block of the periodic table. The three traditional types of elements can be clearly shown in the modern periodic table with the help of this zig-zag line. The metalloid elements lie along the border of this zig-zag line. All the metals lie on the left side of the zig-zag line while all the nonmetals lie on the right side.

Science I
Class 10
Page No. 22

Modern periodic Table and electronic Configuration of Elements

Within a period the neighbouring elements differ slightly in their properties while distant elements differ widely in their properties. Elements in the same group show similarity and gradation in their properties. These characteristics of the groups and periods in the modern periodic table are because of the electronic configuration of the elements. It is the electronic configuration of an element which decides the group and the period in which it is to be placed.

Characteristics of Groups and Periods

The characteristics of the groups and periods in the periodic table are understood by comparison of the properties of the elements. Various properties of all the elements in a group show similarity and gradation. However, the properties of elements change slowly while going from one end to the other (for example, from left to right) in a particular period.

Groups and electronic configuration

Can you tell?

1. Go through the modern periodic table (table no. 2.7) and write the names one below the other of the elements of group 1.
2. Write the electronic configuration of the first four elements in this group.
3. Which similarity do you find in their configuration?
4. How many valence electrons are there in each of these elements?

You will find that the number of valence electrons in all these elements from the group 1, that is, the family of alkali metals, is the same. Similarly, if you look at the elements from any other group, you will find the number of their valence electrons to be the same. For example, the elements beryllium (Be), magnesium (Mg) and calcium (Ca) belong to the group 2, that is, the family of alkaline earth metals. There are two electrons in their outermost shell. Similarly, there are seven electrons in the outermost shell of the elements such as fluorine (F) and chlorine (Cl) from the group 17, that is, the family of halogens. While going from top to bottom within any group, one electronic shell gets added at a time. From this we can say that the electronic configuration of the outermost shell is characteristic of a particular group. However, as we go down a group, the number of shells goes on increasing.

Do you know ?

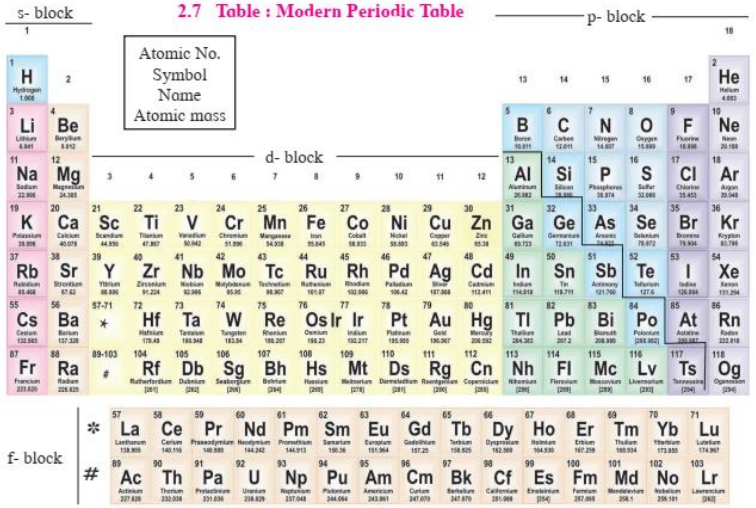
Uranium has atomic number 92. All the elements beyond uranium (with atomic numbers 93 to 118) are manmade. All these elements are radioactive and unstable, and have a very short life.

In the modern periodic table.....

1. Elements are arranged in an increasing order of their atomic numbers.
2. Vertical columns are called groups. There are 18 groups. The chemical properties of the elements in the same group show similarity and gradation.
3. Horizontal rows are called periods. There are in all 7 periods. The properties of elements change slowly from one end to the other in a period.

Science I
Class 10
Page No. 23

2.7 Table : Modern Periodic Table



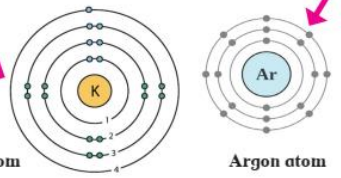
Periods and electronic configuration

Can you tell?

1. On going through the modern periodic table it is seen that the elements Li, Be, B, C, N, O, F and Ne belong to the period-2. Write down electronic configuration of all of them.
2. Is the number of valence electrons same for all these elements?
3. Is the number of shells the same in these ?

You will find that the number of valence electrons is different in these elements. However, the number of shells is the same. You will also find that, while going from left to right, within the period, the atomic number increases by one at a time and the number of valence electrons also increases by one at a time.

	1	2	13	14	15	16	17	18
1	H 1							He 2
2	Li 2,1	Be 2,2	B 2,3	C 2,4	N 2,5	O 2,6	F 2,7	Ne 2,8
3	Na 2,8,1	Mg 2,8,2	Al 2,8,3	Si 2,8,4	P 2,8,5	S 2,8,6	Cl 2,8,7	Ar 2,8,8
4	K 2,8,8,1	Ca 2,8,8,2						
5		Sr						
6		Ba						
7		Ra						



Potassium atom

Argon atom

2.8 New period new shell

ELITE Tutors

Science I
Class 10
Page No. 24

We can say that the elements with the same number of shells occupied by electrons belong to the same period. The elements in the second period, namely, Li, Be, B, C, N, O, F and Ne have electrons in the two shells, K and L. The elements in the third period, namely, Na, Mg, Al, Si, P, S, Cl and Ar have electrons in the three shells; K, L and M. Write down the electronic configuration of these elements and confirm. In the modern periodic table, electrons are filled in the same shell while going along a period from left to right, and at the begining of the next period a new electron shell starts filling up (See the table 2.8).

The number of elements in the first three periods is determined by the electron capacity of the shells and the law of electron octet. (See the Table 2.9)

Can you recall ?

1. hat are the values of 'n' for the shells K, L and M?
2. What is the maximum number of electrons that can be accommodated in a shell? Write the formula.
3. Deduce the maximum electron capacity of the shells K, L and M.

As per the electron holding capacity of shells 2 elements are present in the first period and 8 elements in the second period. The third period also contains only eight elements due to the law of electron octet. There are few more factors which control the filling of electrons in the subsequent periods which will be considered in the next standards.

Shell	n	$2n^2$	Electron Capacity
K	1	$2x1^2$	2
L	2	$2x2^2$	8
M	3	$2x3^2$	18
N	4	$2x4^2$	32

2.9 Electron Capacity of Electron shells

The chemical reactivity of an element is determined by the number of valence electrons in it and the shell number of the valence shell. The information on these points is obtained from the position of the element in the periodic table. That is, the modern periodic table has proved useful for study of elements.

Periodic trends in the modern periodic table

When the properties of elements in a period or a group of the modern periodic table are compared, certain regularity is observed in their variations. It is called the periodic trends in the modern periodic table. In this standard we are going to consider the periodic trends in only three properties of elements; namely, valency, atomic size and metallic- nonmetallic character.

Valency : You have learnt in the previous standard that the valency of an element is determined by the number of electrons present in the outermost shell of its atoms, that is, the valence electrons.

Think about it

1. What is the relationship between the electronic configuration of an element and its valency?
2. The atomic number of beryllium is 4 while that of oxygen is 8. Write down the electronic configuration of the two and deduce their valency from the same.
3. The table on the next page is made on the basis of the modern periodic table. Write in it the electronic configuartion of the first 20 elements below the symbol, and write the valency (as shown in a separate box).
4. What is the periodic trend in the variation of valency while going from left to right within a period? Explain your answer with reference to period 2 and period 3.
5. What is the periodic trend in the variation of valency while going down a group? Explain your answer with reference to the group 1, group 2 and group 18.

Science I
Class 10
Page No. 27

The periodic trend in the metallic character of elements is clearly understood from their position is the modern periodic table. Let us first consider the metallic character of elements belonging to the same group. While going down a group a new shell gets added, resulting in an increase in the distance between the nucleus and the valence electrons. This results in lowering the effective nuclear charge and thereby lowering the attractive force on the valence electrons. As a result of this the tendency of the atom to lose electrons increases. Also the penultimate shell becomes the outermost shell on losing valence electrons. The penultimate shell is a complete octet. Therefore, the resulting cation has a special stability. Due to this, the tendency of the atom to lose electrons increases further. The metallic character of an atom is its tendancy to lose electrons. Therefore, the following trend is observed : The metallic character of elements increases while going down the group.

While going from left to right within a period the outermost shell remains the same. However, the positive charge on the nucleus goes on increasing while the atomic radius goes on decreasing and thus the effective nuclear charge goes on increasing. As a result of this the tendency of atom to lose valenece electrons decreases within a period from left to right (See Table 2.10).

The two factors namely, the increasing nucleur charge and decreasing atomic radius as we go from left to right within a period, are responsible for increasing the effective nuclear charge. Therefore, the valence electrons are held with greater and greater attractive force. This is called electronegativity of an atom. Due to increasing electronegativity from left to right within a period, the ability of an atom to become anion by accepting outside electrons goes on increasing. The tendency of an element to form anion or the electronegativity is the nonmetallic character of an element.

Use your brain power !

1. What is the cause of nonmetallic character of elements?
2. What is the expected trend in the variation of nonmetallic character of elements from left to right in a period?
3. What would be the expected trend in the variation of nonmetallic character of elements down a group?

Always remember

1. While going downwards in any group the electropositivity of elements goes on increasing while their electronegativity goes on decreasing.
2. While going from left to right in any period the electronegativity of elements goes on increasing while their electropositivity goes on decreasing.
3. Larger the electropositivity or electronegativity of the element higher the reactivity.

Gradation in Halogen Family

The group 17 contains the members of the halogen family. All of them have the general formula X_2. A gradation is observed in their physical state down the group.Thus, fluorine (F_2) and chlorine (Cl_2) are gases, bromine (Br_2) is a liquid while iodine (I_2) is a solid.

Internet my friend

Collect the information & mail it

1. Inert gas elements.
2. Uses of various elements.

Read the following reference books from your library.

1. Understanding chemistry - C.N.R. Rao
2. The Periodic Table Book: A Visual Encyclopedia of the Elements

Science I
Class 10
Page No. 28

Do you know ?

$M + 2H_2O \rightarrow M(OH)_2 + H_2$

A general chemical equation indicating the reaction of alkaline earth metals is given above. While going down the second group as Be→ Mg →Ca→Sr→Ba, the gradation in this chemical property of the alkaline earth metals is seen. While going down the second group the reactivity of the alkaline earth metals goes on increasing and thereby the ease with which this reaction takes place also goes on increasing. Thus beryllium (Be) does not react with water. Magnesium (Mg) reacts with steam, while calcium (Ca), strontium (Sr) and barium (Ba) react with water at room temperature with increasing rates.

Exercise

1. Rearrange the columns 2 and 3 so as to match with the column 1.

Column 1	Column 2	Column 3
i. Triad	a. Lightest and negatively charged particle in all the atoms	1. Mendeleev
ii. Octave	b. Concentrated mass and positive charge	2. Thomson
iii. Atomic number	c. Average of the first and the third atomic mass	3. Newlands
iv. Period	d. Properties of the eighth element similar to the first	4. Rutherford
v. Nucleus	e. Positive charge on the nucleus	5. Dobereiner
vi. Electron	f. Sequential change in molecular formulae	6. Moseley

2. Choose the correct option and rewrite the statement.

a. The number of electrons in the outermost shell of alkali metals is.....

(i) 1 (ii) 2 (iii) 3 (iv) 7

b. Alkaline earth metals have valency 2. This means that their position in the modern periodic table is in .....

(i) Group 2 (ii) Group16

(iii) Period 2 (iv) d-block

c. Molecular formula of the chloride of an element X is XCl. This compound is a solid having high melting point. Which of the following elements be present in the same group as X.

(i) Na (ii) Mg (iii) Al (iv) Si

d. In which block of the modern periodic table are the nonmetals found?

(i) s-block (ii) p-block

(iii) d-block (iv) f-block

3. An element has its electron configuration as 2,8,2. Now answer the following questions.

a. What is the atomic number of this element?

b. What is the group of this element?

c. To which period does this element belong?

d. With which of the following elements would this element resemble? (Atomic numbers are given in the brackets)

N (7), Be (4) , Ar (18), Cl (17)

Science I
Class 10
Page No. 30

3. Chemical Reactions and Equations

- Chemical reactions
- Balacing a chemical equation
- Rules of writing chemical reaction
- Types of chemical reactions

Can you recall?

1. What are the types of molecules of elements and compounds?
2. What is meant by valency of elements?
3. What is the requirement for writing molecular formulae of different compounds? How are the molecular formulae of the compounds written?

In earlier standards we have seen how compounds are formed by chemical combination of elements. We have also learnt that the driving force behind formation of a chemical bond is to attain an electronic configuration with a complete octet. The atoms attain a complete octet by giving, taking or sharing of electrons with each other.

Chemical Reaction

Some of the scientists of the 18th and 19th century carried out fundamental experiments on chemical reactions. They proved from their experiments that during chemical reactions composition of the matter changes and that change remains permanent. On the contrary during physical change only the state of matter changes and this change is often temporary in nature.

Identify physical and chemical changes from the phenomena given in the following table.

Phenomenon	Physical change	Chemical change
1. Transformation of ice into water.	✓	
2. Cooking of food.		✓
3. Ripening of fruit.		
4. Milk turned in to curd.		
5. Evaporation of water.		
6. Digestion of food in the stomach.		
7. Size reduction of naphtha balls exposed to air.		
8. Staining of Shahbadi or Kadppa tile by lemon juice.		
9. Breaking of a glass object on falling from a height.		

3.1 Some common phenomenon

Note : Do the following activities in group of friends. Take help of your teacher wherever necessary.

Try this.

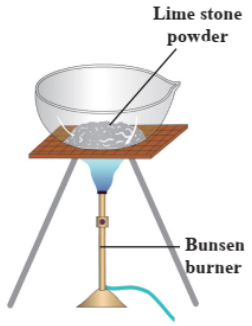
Apparatus: Thermometer, evaporating dish, tripod stand, funnel, Bunsen burner, etc.

Chemicals : Lime stone powder, copper sulphate, calcium chloride, potassium chromate, zinc dust, sodium carbonate, phthalic anhydride, etc.

Procedure : Carry out the activities 1 to 5 as given below. Read and record the temperatures in the activities 2 to 4.

Science I
Class 10
Page No. 31

1. Take a spoonful of lime stone powder in an evaporating dish. Heat it strongly on a high blue flame.
2. Add zinc (Zn) dust into the copper sulphate ($CuSO_4$) solution.
3. Add potassium chromate (K_2CrO_4) solution to barium sulphate ($BaSO_4$) solution.
4. Add sodium carbonate (Na_2CO_3) solution to the calcium chloride ($CaCl_2$) solution.
5. Take phthalic anhydride in the evaporating dish. Close the end of the stem of a funnel with a cotton plug. Keep this funnel inverted on the evaporating dish. Heat the evaporating dish on a tripod stand slowly on a low flame. What did you observe in the funnel during heating?



3.2 To heat lime stone powder

Record the observation of all the activities. What did you find?

Complete the following observation table with reference to the activities 1 to 5.

Activity	Colour change (if present)	Gas released (yes/no)	Temperature change (if present)	Nature of change (chemical /physical)
1				
2				
3				
4				
5				

3.3 Observation table

Find out Observe and keep a record of the physical and chemical changes that you experience in your daily life.

A physical change takes place due to change in the parameters such as temperature, pressure. Often a physical change in reversible. The composition of matter remains the same in a physical change. For example, ice is transformed into water on heating and water is transformed into ice on cooling. On the contrary, if the composition of matter changes during a process then it is called a chemical change. When we call a particular process or phenomenon as a chemical change, some chemical reactions are taking place in the concerned matter.

A chemical reaction is a process in which some substances undergo bond breaking and are transformed into new substances by formation of new bonds. The substances taking part in chemical reaction are called reactants, whereas the substances formed as a result of a chemical reaction by formation of new bonds are called products. For example, formation of carbon dioxide gas by combustion of coal in air is a chemical reaction. In this reaction coal (carbon) and oxygen (from air) are the reactants while carbon dioxide is the product. A chemical reaction is represented by writing a chemical equation.

Science I
Class 10
Page No. 33

$$\text{Vegetable oil (l)} + H_2(g) \xrightarrow[\text{Ni Catalyst}]{60^\circ C} \text{Vanaspathi ghee (s)} \quad \ldots\ldots (6)$$

6 . Special information or names of reactants/ products are written below their formulae. For example, copper on reaction with concentrated nitric acid gives reddish coloured poisonous nitrogen di oxide gas.

$$Cu(s) + 4\,HNO_3(aq) \longrightarrow \underset{\text{(Concentrated)}}{Cu(NO_3)_2(aq)} + 2NO_2(g) + 2H_2O(l) \quad \ldots\ldots (7)$$

However, on reaction with dilute nitric acid, the product formed is nitric oxide gas.

$$3Cu(s) + 8\underset{\text{(dilute)}}{HNO_3}(aq) \longrightarrow 3Cu(NO_3)_2(aq) + 2NO(g) + 4H_2O(l) \quad \ldots\ldots (8)$$

Try this.

Apparatus: Test tube, conical flask, balance, etc.
Chemicals : Sodium chloride and silver nitrate.

Procedure :

1. Take sodium chloride solution in a conical flask and silver nitrate solution in a test tube.
2. Tie a thread to the test tube and insert it carefully into the conical flask. Make the conical flask air tight by fitting a rubber cork.
3. Weigh the conical flask with the help of a balance.
4. Now tilt the conical flask and mix the solution present in the test tube with the solution in the conical flask.
5. Weigh the conical flask again.

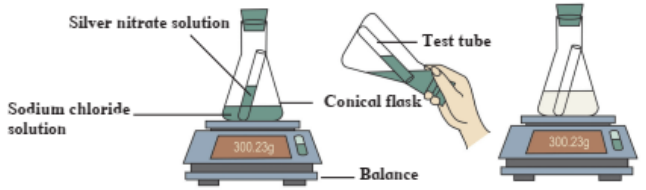
Which changes did you find? Did any insoluble substance form? Was there any change in the weight?

A word equation is written for the above activity as shown below.

Silver nitrate + Sodium chloride ⟶ Silver chloride + Sodium nitrate

The above word equation is represented by the following chemical equation.

$$AgNO_3(aq) + NaCl(aq) \longrightarrow \underset{\text{(white)}}{AgCl\downarrow} + NaNO_3(aq) \quad \ldots\ldots (9)$$



3.4 The reaction of sodium chloride with silver nitrate

Do you know ? Silver nitrate is used in the voters-ink.

Find out What are the other uses of silver nitrate in everyday life?

Science I
Class 10
Page No. 35

$2NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O$ .....(10)'

(ii) Check whether the equation (10)' is balanced or not.

We find that the equation (10)' is not balanced, as the number of oxygen and hydrogen atoms are unequal on the two sides. First balance the hydrogen number as it requires a smaller factor.

(iii) Apply a factor '2' to the product 'H_2O' for balancing the equation (10)'

Now write down the resulting equation (10)".

$2NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O$ .... (10)"

(iv) Check whether the equation (10)" is balanced or not. It is seen that the number of atoms of all the elements are equal on both the sides. It means that the equation (10)" is a balanced equation.

	Reactants (Left side)	Products (Right side)
Element	Number of atoms	Number of atoms
Na	2	2
O	6	5
H	4	2
S	1	1

Step IV : Write down the final balanced equation again.

$2NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O$ ....(11)

In this way, a balanced equation is obtained from an unbalanced equation by applying proper factors to appropriate reactant/product so as to balance the number of each element in steps.

Number of atoms of Hydrogen	In the reactants (In NaOH & H_2SO_4)	In the Products (In H_2O)
i) Initially	4	2
ii) To balance	4	2 x 2

Use your brain power!

1. (a) Identify the reactants and products of equation (6).

(b) Write down the steps in balancing the equation

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

2. Write down a balanced chemical equation for the following reaction

Calcium chloride + Sulfuric acid $\longrightarrow$ Calcium sulphate + hydrogen chloride

3. Write down the physical states of reactants and products in following reactions.

a. $SO_2 + 2H_2S \longrightarrow 3S + 2H_2O$

b. $2Ag + 2HCl \longrightarrow 2AgCl + H_2$

We saw that in a chemical reactions reactants get converted into the new substances called products. During this some chemical bonds in the reactants break and some new chemical bonds are formed so as to transform the reactants into the products. In this chapter we will be studying the types of reactions in detail.

Types of chemical reactions

Chemical reactions are classified into the following four types in accordance with the nature and the number of the reactants and the products.

1. Combination reaction

Try this.

Apparatus: Test tube, glass rod, beaker, etc.
Chemicals: hydrochloric acid, ammonia solution, slaked lime, etc.

Science I
Class 10
Page No. 36

Activity 1: Take a small amount of hydrochloric acid in a test tube. Heat the test tube. Dip a glass rod in the ammonia solution and hold on the top of the test tube. You will observe a white smoke emanating from the tip of the glass rod.

What must have happened?

Due to heating HCl vapours started coming out from the test tube, and NH_3 gas came out from the solution on the glass rod. The ammonia gas and hydrogen chloride gas reacted to form the salt ammonium chloride in gaseous state first, but immediately due to the condensation process at room temperature it got transformed into the solid state. As a result white smoke was formed. The chemical equation for this is as follows.

$$NH_3(g) + HCl(g) \longrightarrow NH_4Cl(s) \quad \ldots\ldots (12)$$

Ammonia Hydrogen chloride Ammonium chloride

Activity 2: Hold a magnesium (Mg) strip in a pair of tongs and ignite. On burning in air a white powder of magnesium oxide is formed. The reaction can be written in the form of equation as shown below.

$$2Mg + O_2 \longrightarrow 2MgO \quad \ldots\ldots (13)$$

In this reaction magnesium oxide is formed as the single product by combination of magnesium and oxygen.

Activity 3: Take water in a beaker up to half of its capacity. Add a few pieces of slaked lime (calcium oxide, CaO) to it. Calcium hydroxide ($Ca(OH)_2$) is formed by combination of calcium oxide and water with generation of large amount of heat.

$$CaO + H_2O \longrightarrow Ca(OH)_2 + \text{Heat} \quad \ldots\ldots (14)$$

Calcium oxide calcium hydroxide

Use your brain power!

1. What is the number of reactants in each of the above reactions?
2. What is the number of molecules of reactants taking part in the above reactions?
3. How many products are formed in each of the above reactions?

When two or more reactants combine in a reaction to form a single product, it is called a combination reaction.

2. Decomposition reaction

Try this.

Apparatus: Evaporating dish, Bunsen burner, etc.
Chemicals : Sugar, calcium carbonate, sulphuric acid, etc.

Procedure: Take some sugar in an evaporating dish and heat it with the help of a Bunsen burner. After some time you will see the formation of a burnt out black substance. Exactly what must have happened in this activity?

In the above activity a single reactant sugar is divided into two substances (C and H_2O)

$$C_{12}H_{22}O_{11} \longrightarrow 12C + 11H_2O \quad \ldots\ldots (15)$$

Sugar carbon

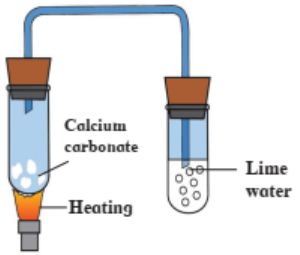
The reaction in which there is only one reactant giving rise to two or more products is called a decomposition reaction.

Science I
Class 10
Page No. 37

Try this. **Apparatus :** Two test tubes, bent tube, rubber cork, burner, etc.

Chemicals : Calcium carbonate, freshly prepared lime water.

Procudure : Take some calcium carbonate in a test tube. Fit a bent tube to this test tube with the help of a rubber cork. Insert the other end of the bent tube in the freshly prepared lime water taken in the other test tube. Heat the powdered calcium carbonate in the first test tube strongly. The lime water will turn milky.



3.6 Decomposition of calcium carbonate

We saw in the above activity that calcium carbonate undergoes decomposition reaction and the carbon dioxide gas formed turns the lime water milky (Eq. 16). The second product of the reaction, the calcium oxide powder, remains behind in the first test tube. Similarly, in another reaction (Eq. 17) hydrogen peroxide naturally undergoes slow decomposition into water and oxygen.

$CaCO_3(s) \xrightarrow{\Delta} CaO(s) + CO_2\uparrow$ ..... (16); $2H_2O_2(l) \rightarrow 2H_2O(l) + O_2\uparrow$ .... (17)

(16) and (17) both are decomposition reactions.

Can you recall? Is it possible to produce hydrogen by decomposition of water by means of heat, electricity or light ?

We have studied in the previous standard that water decomposes into hydrogen and oxygen gases on passing electric current through acidulated water. This decomposition takes place by means of electrical energy. Therefore it is called electrolysis.

$2H_2O(l) \longrightarrow 2H_2\uparrow + O_2\uparrow$ .....(18)

The chemical reaction in which two or more products are formed from a single reactant is called "Decomposition reaction".

Many degradation precesses take place in the nature surrounding us. Organic waste is decomposed by microorganisms and as a result manure and biogas are formed. Biogas is used as a fuel.

Science I
Class 10
Page No. 39

To carry out endothermic and exothermic processes

Try this.

Apparatus : Two plastic bottles, measuring cylinder, thermometer etc.
Chemicals : Potassium nitrate, sodium hydroxide, water etc.
(Sodium hydroxide being corrosive, handle it carefully in presence of Teacher.)

Procedure : Take 100 ml water in each of the two plastic bottles. Plastic being insulator of heat, the dissipation of heat can be prevented. Note the temperature of water in the bottles. Put 5 g potassium nitrate (KNO_3) in the bottle and shake well. Note the temperature of the solution formed. Put 5 g sodium hydroxide (NaOH) in the other bottle. Shake the bottle well. Note the temperature.

In the first bottle the process of dissolution of potassium nitrate took place while in the second bottle the process of dissolution of sodium hydroxide took place. As per your observation which one is exothermic process and which is an endothermic process?

During the process of the dissolution of KNO_3 in water, heat from the surroundings is absorbed and therefore the temperature of the resulting solution is less. The process in which heat is absorbed from the outside, is called endothermic process. When the solid NaOH is dissolved in water heat is given out, and therefore the temperature increases. The processes in which heat is given out are called exothermic processes.

Endothermic and Exothermic Reactions

There is an exchange of heat in chemical reactions as well. Accordingly some chemical reactions are exothermic while some other are endothermic. During exothermic chemical reactions heat is given away when reactants are transformed into the products, while during endothermic chemical reactions heat is either absorbed from the surroundings or has to be supplied continuously from outside. For example,

$CaCO_3$ (s) + heat ⟶ CaO (s) + CO_2(g) **(Endothermic Reaction)**

CaO (s) + H_2O (*l*) ⟶ $Ca(OH)_2$ (aq) + heat **(Exothermic Reaction)**

Use your brain power !

1. What is the difference in the process of dissolution and a chemical reaction ?
2. Does a new substance form when a solute dissolves in a solvent ?

Rate of Chemical Reaction

Can you tell?

Take into account the time required for following processes. Classify them into two groups and give titles to the groups.

1. Cooking gas starts burning on ignition .
2. Iron article ungergoes rusting.
3. Errosion of rocks takes place to form soil.
4. Alcohol is formed on mixing yeast in glucose solution under proper condition.
5. Effervescence is formed on adding baking soda into a test tube containing dilute acid.
6. A white precipitate is formed on adding dilute sulphuric acid to barium chloride solution.

It can be seen from the above examples that some reactions are completed in short time, that is, occur rapidly, while some other require long time for completion, that is, occur slowly. It means that the rate of different reactions is different.

Science I
Class 10
Page No. 41

e. Catalyst

On heating potassium chlorate ($KClO_3$) decomposes slowly.

$$2KClO_3 \xrightarrow{\Delta} 2KCl + 3O_2 \text{ ..... (19)}$$

The rate of the above reaction neither increases by reducing the particle size nor by increasing the reaction temperature. However, $KClO_3$ decomposes rapidly in presence of manganese dioxide (MnO_2) to liberate O_2 gas. No chemical change takes place in MnO_2 in this reaction.

"The substance in whose presence the rate of a chemical reaction changes, without causing any chemical change to it, is called a catalyst."

The decomposition of hydrogen peroxide into water and oxygen takes place slowly at room temperature (Eq. 17). However, the same reaction occurs at a faster rate on adding manganese dioxide (MnO_2) powder in it.

Do you know ?

1. One or more chemical reactions take place during every chemical change.
2. Some chemical reactions occur at fast speed whereas some occur at slow speed.
3. Strong acid and strong base react instantaneously.
4. In our body, enzymes increase the rate of physiological reactions.
5. Perishable foodstuff gets preserved longer in a refrigerator. The rate of decomposition of foodstuff gets lowered due to low temperature, and its freshness is maintained.
6. Vegitables cook quickly on oil rather than on water.
7. The chemical reactions are profitable in the chemical factories if their rate is fast.
8. The rate of chemical reaction is important from environmental point of view as well.
9. The ozone layer in the earth's atmosphere protects the life on earth from the ultraviolet radiation of the sun. The process of depletion or maintenance of this layer depends upon the rate of production or destruction of ozone molecules.

Oxidation and Reduction

Many types of substances give reactions called oxidation and reduction. Let us learn more about these reaction.

$$2Mg + O_2 \longrightarrow 2MgO \text{ .....(20)}$$
$$C + O_2 \longrightarrow CO_2 \text{ .....(21)}$$
$$MgH_2 \longrightarrow Mg + H_2 \text{ .....(22)}$$
$$CH_3\text{-}CH_3 \longrightarrow CH_2 = CH_2 \text{ ....(23)}$$

In the reactions (20) and (21) a reactant combines with oxygen, whereas in (22) and (23) hydrogas is removed from the reactant. All these are examples of the oxidation reaction.

The chemical reaction in which a reactant combines with oxygen or loses hydrogen to form the product is called oxidation reaction.

Science I
Class 10
Page No. 42

Some oxidation reactions are brought about by use of specific chemical substances. For example,

$CH_3 - CH_2 - OH \xrightarrow[K_2Cr_2O_7/H_2SO_4]{[O]} CH_3 - COOH$ ..... (24)

Ethyl alcohol — Acetic acid

Here the acidic potassium dichromate makes oxygen available for the oxidation of the reactant ethyl alcohol. Such chemical substances which bring about an oxidation reaction by making oxygen available are called oxidants or oxidizing agents.

Do you know ?

A variety of oxidants are used to bring about a controlled oxidation. $K_2Cr_2O_7/H_2SO_4$, $KMnO_4/H_2SO_4$ are the commonly used chemical oxidants. Hydrogen paroxide (H_2O_2) is used as a mild oxidant. Ozone (O_3) is also a chemical oxidant. Nascent oxygen is generated by chemical oxidants and it is used for the oxidation reaction.

$O_3 \rightarrow O_2 + [O]$

$H_2O_2 \rightarrow H_2O + [O]$

$K_2Cr_2O_7 + 4H_2SO_4 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3\,[O]$

$2KMnO_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5\,[O]$

Nascent oxygen is a state prior to the formation of the O_2 molecule. It is the reactive form of oxygen and is represented by writing the symbol as [O].

Use your brain power !

1. Which is the oxidant used for purification of drinking water?
2. Why is potassium permanganate used during cleaning water tanks?

We have seen just now that potassium permanganate is a chemical oxidant. Now have a look at the following reaction.

$2KMnO_4 + 10FeSO_4 + 8H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 5Fe_2(SO_4)_3 + 8H_2O$ ..... (25)

Which compound is oxidised by $KMnO_4$ in presence of acid in this reaction? Of course $FeSO_4$.

Here $FeSO_4$ is transformed into $Fe_2(SO_4)_3$. Let us now see, how this conversion is an oxidation reaction.

$2FeSO_4 \rightarrow Fe_2(SO_4)_3$

Ionic reaction $\quad Fe^{2+} + SO_4^{2-} \rightarrow 2Fe^{3+} + 3SO_4^{2-}$

The net change taking place in the above conversion is shown by the net ionic reaction as shown below.

Net ionic reaction $\quad Fe^{2+} \rightarrow Fe^{3+}$

(Ferrous) (Ferric)

This net ionic reaction represents the oxidation brought about by $KMnO_4$. When ferric ion is formed from ferrous ion the positive charge is increased by one unit. While this happens the ferrous ion loses one electron. From this, we understand a new defination of oxidation, which is "oxidation means losing one or more electrons."

Science I
Class 10
Page No. 43

Can you tell? Look at the chemical equation (6). What is the type of this reaction, in which vanaspathi ghee is formed from vegetable oil?

The chemical reactions in which reactants gain hydrogen are called 'reduction' reactions. Similarly, the reaction in which a reactant loses oxygen to form the product is also called reduction reaction. The substance that brings about reduction is called a reductant, or a reducing agent.

When hydrogen gas is passed over black copper oxide a reddish coloured layer of copper is formed.

$$CuO + H_2 \longrightarrow Cu + H_2O \quad \ldots\ldots\ldots\ldots (26)$$

Which is the reductant in this reaction? And which reactant has undergone reduction?

In this reaction an oxygen atom goes away from CuO (copper oxide), which means that reduction of copper oxide takes place, whereas hydrogen molecule takes up oxygen atom and water (H_2O) is formed meaning, oxidation of hydrogen takes place. Thus oxidation and reduction reactions occur simultaneously. The reductant is oxidized by the oxidant and the oxidant is reduced by the reductant. Due to this characteristics of the reduction and oxidation reactions, a single term 'redox reaction' is used in place of the two terms.

Redox Reaction = Reduction + Oxidation

Use your brain power !

1. Some more examples of redox reaction are as follows. Identify the reductants and oxidants from them.

$$2H_2S + SO_2 \longrightarrow 3S\downarrow + 2H_2O \quad \ldots\ldots\ldots\ldots (27)$$

$$MnO_2 + 4\,HCl \longrightarrow MnCl_2 + 2H_2O + Cl_2\uparrow \quad \ldots\ldots\ldots\ldots (28)$$

2. If oxidation means losing electrons, what is meant by reduction?
3. Write the reaction of formation of Fe^{2+} by reduction Fe^{3+} by making use of the symbol (e^-).

Think about it The luster of the surface of the aluminium utensils in the house is lost after a few days. Why does this happen?

When the positive charge on an atom or an ion increases or the negative charge on them decreases it is called oxidation, and when the positive charge decreases or the negative charge increases it is called reduction.

$$Fe \underset{\text{reduction}}{\overset{\text{oxidation}}{\rightleftharpoons}} FeO \underset{\text{reduction}}{\overset{\text{oxidation}}{\rightleftharpoons}} Fe_2O_3$$

Do you know ?

A redox reaction takes place during cellular respiration. Here the molecule of the enzyme called cytochrome C oxidase helps the transport of electron to bring about this reaction.

For more information refer to life processes in the living organisms.

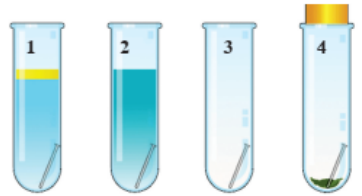
Science I
Class 10
Page No. 44

Corrosion

Try This.

Apparatus : Four test tubes, four small iron nails, rubber cork, etc.
Chemicals : Anhydrous calcium chloride, oil, boiled water, etc.

Procedure : Place four test tubes on a test tube stand. Take some boiled water in one test tube and put an oil layer on it. Take some salt water in the second test tube. Let there be only air in the third test tube. Take some anhyrous calcium chloride in the fourth test tube. Place a small iron nail in every test tube. Close the fourth test tube with a rubber cork. Let all the four test tubes remain un attended for a few days.



3.7 To study rusting

Observe all the four test tubes after a few days. What did you find? Which test tubes had the nails as before? Both water and air are necessary for rusting. The rusting process takes place rapidly in presence of a salt. Have you seen the effect of redox reaction in your everyday life? The new vehicles look shiny, on the contrary old vehicles look dull. A certain type of reddish coloured solid layer collects on their metallic surface. This layer is called 'rust'. Its chemical formula is $Fe_2O_3 \cdot X\,H_2O$.

The rust on iron does not form by a simple reaction of oxygen with iron surface. The rust is formed by an electrochemical reaction. Different regions on the surface of iron become anode and cathode.

1. Fe is oxidised to Fe^{2+} in the anode region.

$$Fe\,(s) \longrightarrow Fe^{2+}\,(aq) + 2\,e^-$$

2. O_2 is reduced to form water in the cathode region.

$$O_2\,(g) + 4H^+\,(aq) + 4\,e^- \longrightarrow 2H_2O\,(l)$$

When Fe^{2+} ions migrate from the anode region they react with water and further get oxidised to form Fe^{3+} ions.

A redish coloured hydrated oxide is formed from Fe^{3+} ions. It is called rust. It collects on the surface.

$$2Fe^{3+}(aq) + 4H_2O\,(l) \longrightarrow Fe_2O_3 \cdot H_2O\,(s) + 6H^+\,(aq) \quad \ldots\ldots\ldots (29)$$

Due to various components of atmospliere, oxidation of metals takes place, consequently resulting in their damage. This is called 'corrosion'. Iron rusts and a redish coloured layer is collected on it. This is corrosion of iron. Corrosion is a very serious problem . We are going to study about it in the next chapter.

Find out

How are the blackened silver utensils and patinated (greenish) brass utensils cleaned?

Science I
Class 10
Page No. 46

6. Identify from the following reactions the reactants that undergo oxidation and reduction.

a. $Fe + S \longrightarrow FeS$

b. $2Ag_2O \longrightarrow 4\,Ag + O_2\uparrow$

c. $2Mg + O_2 \longrightarrow 2MgO$

d. $NiO + H_2 \longrightarrow Ni + H_2O$

7. Balance the following equation stepwise.

a. $H_2S_2O_3(l) + H_2O(l) \longrightarrow H_2SO_4(l)$

b. $SO_2(g) + H_2S(aq) \longrightarrow S(s) + H_2O\,(l)$

c. $Ag(s) + HCl(aq) \longrightarrow AgCl\downarrow + H_2\uparrow$

d. $NaOH\,(aq) + H_2SO_4(aq) \longrightarrow Na_2SO_4(aq) + H_2O(l)$

8. Identify the endothermic and exothermic reaction.

a. $HCl + NaOH \longrightarrow NaCl + H_2O + heat$

b. $2KClO_3(s) \xrightarrow{\Delta} 2KCl(s) + 3O_2\uparrow$

c. $CaO + H_2O \longrightarrow Ca(OH)_2 + heat$

d. $CaCO_3(s) \xrightarrow{\Delta} CaO(s) + CO_2\uparrow$

9. Match the column in the following table.

Reactants	Products	Type of chemical reaction
$BaCl_2(aq) + ZnSO_4(aq)$	$H_2CO_3(aq)$	Displacement
$2AgCl(s)$	$FeSO_4(aq) + Cu(s)$	Combination
$CuSO_4(aq) + Fe(s)$	$BaSO_4\downarrow + ZnCl_2(aq)$	Decomposition
$H_2O(l) + CO_2(g)$	$2Ag(s) + Cl_2(g)$	Double displacement

Project

Prepare aqueous solutions of various solid salts available in the laboratory. Observe what happens when aqueous solution of sodium hydroxide is added to these. Prepare a chart of double displacement reactions based on these observation.

HZQQVQ

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Science I
Class 10
Page No. 47

4. Effects of electric current

- Energy transfer in electric circuit.
- Heating effects of electric current.
- Magnetic effects of electric current.

Can you recall?

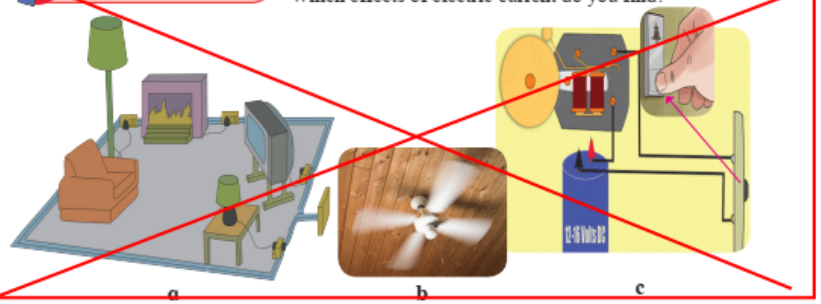
1. How do we decide that a given material is a good conductor of electricity or is an insulator?
2. Iron is a conductor of electricity, but when we pick up a piece of iron resting on the ground, why don't we get electric shock?

We have learnt in earlier standards about static electricity. We performed various experiments regarding negatively and positively charged objects. The reason behind the object becoming positively and negatively charged is the transfer of negatively charged particles from one object to another object. In previous standard, we also studied about electric current.

In this chapter, we will study about an electric current flowing through a conducting wire, an electric current flowing through a resistor, electromagnetic induction, electric motor and generator.

Observe and Discuss

What do you observe in the following pictures?
Which effects of electric current do you find?



a b c

4.1 Effects of electric current

Energy transfer in an electric circuit

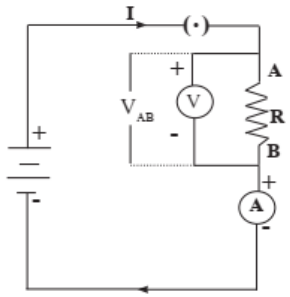
Try this

Materials: connecting wires, electric cells, electrical resistance, voltmeter, ammeter, plug key.

Procedure: Connect the circuit as shown in the accompanying figure 4.2 after taking the components with proper values. Measure the current (I). Also measure the potential difference (V_{AB}) between the two ends (A and B) of the resistance.

The potential at A is higher than the potential at B as the point A is connected to the positive electrode of the cell and the point B to the negative electrode of the cell.

Science I
Class 10
Page No. 48



4.2 Electric circuit

If a charge Q flows from A to B, work V_{AB} Q, has been done on Q while going from A to B (Refer to chapter 3 of std 9). From where does the energy come to do this work? The source of energy is the cell. The cell gives this energy through the charge Q to the resistance where work V_{AB} Q is performed. If the charge Q flows from A to B in time t, i.e. the work is performed in time t, then during that time the energy V_{AB} Q is given to the resistor.

What happens to this energy? This energy is received by the resistor and is converted into heat energy, the temperature of the resistor is increased.

Use your brain power !

If in the circuit, the resistor is replaced by a motor, in which form will the energy given by the cell get transformed into?

P = Electrical power = $\frac{\text{Energy}}{\text{Time required}} = \frac{V_{AB}\,Q}{t} = V_{AB}\,I$ .....(1) $\because \frac{Q}{t} = I$,

The source of energy, the cell, gives in time t, the energy P x t to the resistor. If I is the current flowing continuously through the circuit, the heat produced in the resistor in time t will be

$H = P \times t = V_{AB} \times I \times t$ ..... (2)

According to Ohm's law,

$V_{AB} = I \times R$ ..... (3)

$H = V^2_{AB} \times \frac{t}{R}$ ..... (4)

Similarly, $H = I \times I \times R \times t = I^2 \times Rt$ ..... (5)

$H = I^2 \times R \times t$ is called Joules law of heating

Unit of electrical power

$P = V_{AB} \times I$ = Volt x Amp ..... (6)

1 Volt x 1 Amp = $\frac{1J}{1C} \times \frac{1C}{1s}$ ..... (7)

$\frac{1J}{s} = W$ (watt) ..... (8)

Thus the unit of electrical power is 1W (watt).

Think about it

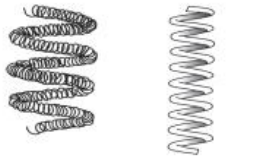
How can we write mechanical power in a manner similar to the electrical power?

Heating effect of electric current

When a resistor is connected in an electrical circuit, heat is produced in it due to the current. This is known as the heating effect of current.

ELITE Tutors

Science I
Class 10
Page No. 49



Coiled coil Coil (Solenoid type)

Coil of cooker Coil of Heater

Equipment such as water boiler, electric cooker, electric bulb make use of the heating effect of electric current. Electrical conductors having higher resistivity are used here. For example, a coil made up of an alloy Nichrome is used in the electric heater-cooker as a resistor, while a tungsten wire is used in an electric bulb. Because of the current, this wire gets heated (to nearly 3400 °C) and emits light. The hot wire also radiates heat to a certain extent.

Always remenber

The unit of electric power 1W is a very small unit, hence 1000 W or 1 kW is used as a unit to measure electric power, in practice. If 1 kW power is used for 1 hour, it will mean 1kW × 1 hr of electrical energy is used (see equation 1)

1kWh = 1 kilowatt hour = 1000 W × 3600 s = 3.6×10^6 Ws = 3.6×10^6 J

4.3 Uses of coil

Find out

Check monthly electricity bill received from the electricity distribution Co. Ltd. Observe various details and get information about them. The electricity bill specifies the usage in 'Units'. What is this unit? When 1 kWh electrical energy is used, it is termed as 1 unit of energy.

Several times we hear or read about a building catching fire due to short circuit. Sometimes, if we switch on an equipment in our house, the electrical fuse wire melts and the electric supply shuts down. Let us discuss about the cause briefly. The home electrical connection consists of 'live', 'neutral' and 'earth' wires. The 'live' and the 'neutral' wires have potential difference of 220V. The 'earth' is connected to ground. Due to a fault in the equipment or if the plastic coating on the 'live' and the 'neutral' wires gives way, the two wires come in contact with each other and a large current flows through it producing heat. If any inflammable material (such as wood, cloth, plastic etc) exists around that place it can catch fire. Therefore, a fuse wire is used as a precautionary measure. We have learnt about fuse wire in the previous standard. As soon as high current flows in a circuit, the fuse wire melts and breaks the circuit and any mishap is avoided.

Science I
Class 10
Page No.50

Many times particularly in the summer season, huge electrical power is used in the evenings due to home lighting, fans, air conditioners, use of electricity in shops etc. As a result, excessive current is drawn from the transformer supplying the electricity, and if the capacity of the transformer is insufficient, its fuse wire melts and the supply gets shut down. Such events occur due to overloading.

4.4 Different types of fuses in use

Do you know ?

These days' miniature circuit breakers (MCB) switches are used in homes. When the current in the circuit suddenly increases this switch opens and current stops. Different types of MCBs are in use. For the entire house, however the usual fuse wire is used.

Solved examples

Example 1. A 6 m long wire made from an alloy, nichrome, is shaped into a coil and given for producing heat. It has a resistance of 24 ohms. Can we get more heat if the wire is cut into half of its original length and shaped into a coil? For getting energy, the two ends of the wire are connected to a source with a potential difference of 220V.

Given : Resistance 24 ohm, potential difference = 220 V

A. Coil of whole wire.

$$P = \frac{V^2}{R} = \frac{(220)^2}{24} = 201 \text{ watts}$$

B. Coil of half-length wire

$$P = \frac{V^2}{R} = \frac{(220)^2}{12} = 403 \text{ watts}$$

This means that more heat will be obtained after cutting the wire into half.

Example 2. A cell is connected to a 9 ohm resistance, because of which heat of 400 J is produced per second due to current flowing through it. Obtain the potential difference applied across the resistance.

Given:

Heat at 400 J per second means

$$P = \frac{400 \text{ J}}{1 \text{ s}}$$

$$P = \frac{V^2}{R}$$

$$400 = \frac{V^2}{9}$$

$$400 \times 9 = V^2$$

$$\therefore V = \sqrt{(400 \times 9)} = 20 \times 3 = 60 \text{ V}$$

Page No.51
Example
1 and 2

ELITE Tutors

Science I
Class 10
Page No. 51

Example 3. An electrical iron uses a power of 1100 W when set to higher temperature. If set to lower temperature, it uses 330 W power. Find out the electric current and the respective resistances for the two settings. The iron is connected to a potential difference of 220 V.

Given: potential difference = 220 V.

Power P = (A) 1100 W, (B) = 330 W.

A. Power = 1100 W.

$$I_1 = \frac{P}{V} = \frac{1100}{220} = 5 \text{ A}$$

B. Power = 330 W

$$I_2 = \frac{P}{V} = \frac{330}{220} = 1.5 \text{ A}$$

Resistance $R_1 = \frac{V}{I_1} = \frac{220}{5} = 44\ \Omega$

Resistance $R_2 = \frac{V}{I_2} = \frac{220}{1.5} = 146\ \Omega$

Example 4. An electric tungsten bulb is connected into a home circuit. The home electric supply runs at 220 V potential difference. When switched on, a current of 0.45 A flows through the bulb. What must be power (wattage) of the bulb? If it is kept on for 10 hours, how many units of electricity will be consumed?

Given : Potential difference = 220 V.

Current = 0.45 A.

Power (W) = Potential difference(V) x Current (A)

= 220 x 0.45 W

= 99 W.

The bulb must be of power 99 W.

In 10 hrs,

99 W x 10 h =990 Wh.

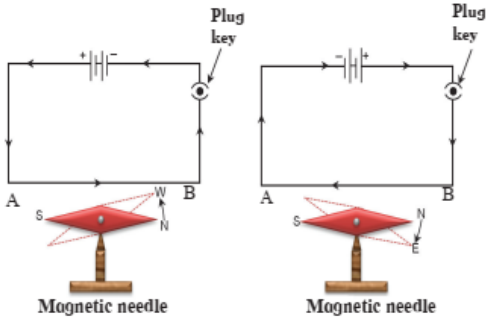
= 0.99 kWh.

Magnetic effect of electric current

We have learnt about heating effect of electric current. In previous standards, we have studied about magnets and magnetic lines of force. However, it will be interesting to see if an electric current and magnetic field are related to each other.

Try this

Connect the circuit as shown in figure 4.5. Connect a copper wire, thicker and straight as compared to the connecting wires, between A and B. Keep a magnetic needle adjacent to the wire. Keep the plug key open in the circuit and observe the direction of the needle. Close the plug key and observe the direction of the needle. What do you notice? Now interchange the connecting wires connected to the cell and observe the direction of the magnetic needle. Do you notice any relation between the direction of current and position of the needle?



ELITE Tutors

Science I
Class 10
Page No. 52

What do you learn from this experiment? The magnetic effect is observed because of the current in the wire. This means electricity and magnetism are closely related! On the contrary, if a magnet is moved and kept moving, will we observe any electric effect? Is it not exciting? Therefore, we are going to study magnetic fields and such 'electromagnetic' effects. Finally, we will study the principles, construction and working of electric motor and electric generator.

Introduction of Scientist

Hans Christian Oersted (1777-1851)

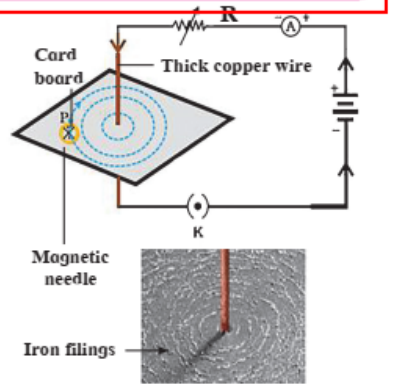
As a scientist at the forefront in the 19th century, Hans Christian Oersted played an important role in understanding 'electromagnetism'. He observed, in 1820, that when a current passes through a metal wire, the magnetic needle near the wire turns through a certain angle. He pointed out the relation between electricity and magnetism. Today's advanced technology is developed as a consequence. In his honour, the unit of intensity of the magnetic field is termed as Oersted.

Try this

Connect the circuit as shown in fig. 4.6 When a large current (approximately 1A or more) flows through the thick copper wire passing through a cardboard, the magnetic needle kept at different points on the cardboard around the wire stands in different directions. Mark these directions with a pencil.
(Discuss with your friends and teachers about the requirement of the current, number of cells, cells of what potential difference, thickness of the wire etc., and then perform the experiment). The direction of the current shown in the circuit is its convential direction.

What changes are caused by increasing or decreasing current? What do you see when the magnetic needle is kept a little away from the wire? Now, instead of the magnetic needle, spread iron filings on the cardboard and observe. The iron filings arrange themselves in a circular manner around the wire. Why does this happen?

You have studied magnetism and magnetic field in previous standard. The iron filings spread along the magnetic lines of force.



4.6 Magnetic field produced around the conductor

Always remember

A magnetic field is produced around a straight current carrying conductor. If the current is unchanged, this magnetic field reduces as the distance from the wire increases. Therefore, the concentric circles representing the magnetic lines of force are shown bigger and rarefied as the distance from the wire increases. If the current through the wire is increased, the intensity of the magnetic field increases.

Science I
Class 10
Page No. 57

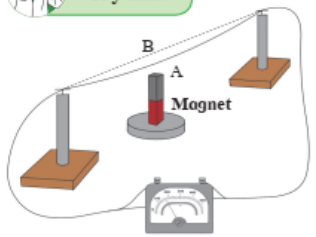
Galvanometer

Galvanometer is a sensitive device which works on the same principle as that of an electric motor that we have studied earlier. We can make some electrical measurements with it. A coil is positioned between the pole pieces of a magnet in such a way that the pointer on the galvanometer dial is connected to it. When a small current (for example 1 mA) flows through the coil, the coil will rotate. The rotation will be proportional to the current. Voltmeter and Ammeter also work on the same principle. In galvanometer, the pointer deflects on both the sides of the zero mark depending on the direction of the current.

4.14 Galvanometer

Try this.

Collect the material as shown in figure 4.15. Complete the circuit by connecting the galvanometer. Keep the bar magnet erect in such a way that its north or south pole is just below the copper wire. Now if the wire is kept moving from A ——→ B , the pointer of the galvanometer gets deflected. This is called Faraday's electromagnetic induction. Now move the magnet with the wire fixed. The Galvanometer pointer still gets deflected.

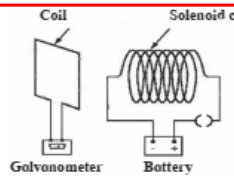


4.15 If a conducting wire is kept moving in a magnetic field, a current is produced in it.

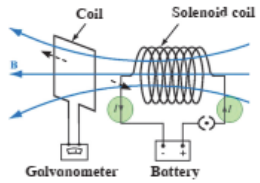
Try this.

Complete the circuit as shown in figure 4.16a. Discuss about and select the components as required. In this experiment, if we open the plugkey and make the current zero in the coil, the pointer of the Galvanometer deflects to a side and quickly comes back to zero. If the current in the coil is started again, the pointer again deflects to the other side and then returns quickly to zero.

Now when the electrical current is flowing through the solenoid coil and the solenoid coil is displaced with respect to the coil, the current is still produced in the coil.



4.16 (a) When the current in the solenoid coil is switched on or off



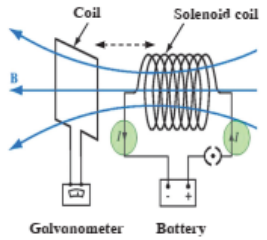
4.16 (b) when a current is passing through the solenoid coil and the coil is displaced laterally with respect the coil

ELITE Tutors

Science I
Class 10
Page No. 58

What can be inferred from these two experiments?

Even if the solenoid coil is kept stationary, a change in current in the solenoid coil produces a current in the coil. If the solenoid coil is moved towards or away from the coil, we see a deflection in the Galvanometer (fig 4.16c) Also, the faster is the displacement of the solenoid, larger is the deflection of the Galvanometer pointer. If the current in the solenoid coil is changed, a current is produced in the coil or if the solenoid coil is moved towards the coil, then also a current is produced in the coil.



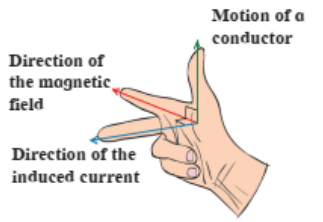
4.16 c) When a current passing through the solenoid coil and the solenoid coil is displaced longitudinally with respect to the coil

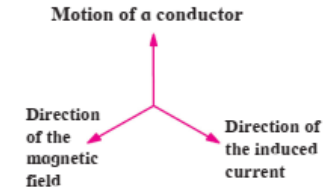
Faraday's law of induction:

If a current is switched on or off in the solenoid coil, a current is induced in the coil. Such as induction is also observed when the current in the solenoid coil is incresed or decreased. Current is induced in the coil when it is moved aside from front of the solenoid. From these experiments it is understood that whenever the number of magnetic lines of force passing through the coil changes, current is induced in the coil. This is known as Faraday's law of induction. The current produced in the coil is called the induced current.

Fleming's right hand rule :

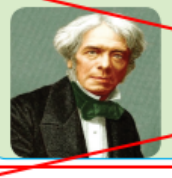
When will the induced current in the electrical conductor (coil) be maximum? It will be maximum when the direction of motion of the electric conductor is perpendicular to the magnetic field. In order to show the direction of the induced current, Fleming's right hand rule is very useful. Stretch the thumb, the index finger and the middle finger in such a way that they will be perpendicular to each other. In this position, the thumb indicates the direction of motion of the conductor, the index finger the direction of the magnetic field, and the middle finger shows the direction of the induced current. This rule is known as Fleming's right hand rule (fig 4.17).





4.17 Fleming's right hand rule

Introduction to Scientist

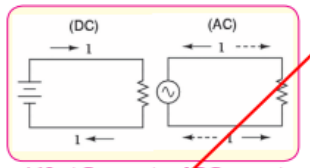


Michael Faraday (1791-1867) was an experimental scientist. He was not formally educated. Teenager Michael started working in a bookbinding shop. While reading books there, he got interested in science. Sir Humphrey Davy appointed him as a laboratory assistant in the Royal Institute London. There he discovered the laws of electrmagnetic induction and the laws of electrolysis. Several Universities offered him honorary degree, but Faraday refused to accept such honours.

Science I
Class 10
Page No. 59

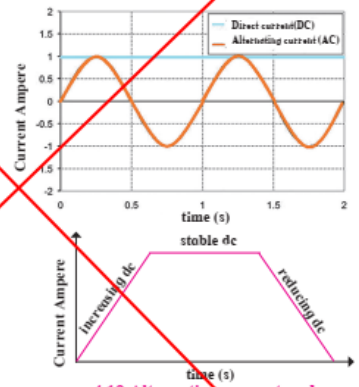
Alternating current (AC) and Direct Current (DC)

So far we have learnt about a non oscillatory current flowing in one direction, in a circuit, from the cell to the cell. Such a current is called a direct current (DC) as against a current changing in magnitude and direction after equal intervals of time which is called alternating current (AC).



4.18 AC current and DC current

The direct current can increase, can be stable, or can reduce also, but it is not oscillatory. This is shown graphically in the figure. Alternating current is oscillatory. As shown in the graph (fig 4.19), it increases to a maximum, then reduces to zero and increases to maximum in the other direction and again reduced to zero. (in the figure, magnitudes like -1, -2 have been used to show the reverse direction). The oscillation of the alternating current occurs in a sinusoidal manner with time and hence is shown by the symbol ~. Direct current flows in one direction, but the alternating current flows in periodic manner, in one cycle, in forward and reverse directions.



4.19 Alternating current and Direct current (Graphical)

In india, in the power stations generating electricity, one cycle changes in $\frac{1}{50}$ second i.e. the frequency of AC is 50 Hz (50 cycles per second). When the electric power is transmitted over a long distance, it is beneficial to have it in AC form as it results into minimum power loss during transmission. The home supply is of alternating current (AC). We have learnt in the previous class about the precautions to be taken while using the electricity.

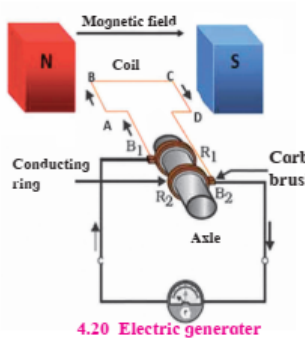
Electric Generator

We have seen the experiments based on electromagnetic induction. The current produced in these experiments was of very small magnitude. But the same principle can be harnessed for the use of mankind to produce large current. Here, mechanical energy is used to rotate the current carrying coil in a magnetic field, around an axle, thereby producing electricity.

Fig 4.20 shows a copper wire coil ABCD, kept between th e two pole pieces of a magnet. The two ends of the coil are conected to the conducting rings R_1 and R_2 via carbon brushes. Both the rings are fixed to the axle, but there is a resistive coating in between the ring and the axle. The axle is rotated with the help of a machine from outside. Because of this, the coil ABCD starts rotating. The stationary carbon brushes B_1 and B_2 are connected to a galvanometer, which shows the direction of current in the circuit. Upon rotating the axle, the branch AB goes up and the branch CD goes down (i.e. the coil ABCD rotates clockwise).

Science I
Class 10
Page No. 60

According to Fleming's right hand rule, electric current is produced in the branches AB and CD in the direction. A → B and C → D. Thus, the current flows in the direction A → B → C → D (as shown by arrows in the figure). In the external circuit, the current flows from B_2 to B_1 through the galvanometer. If instead of one loop coil, a coil consisting of several turns is used, the current of magnitude several times flows. After half rotation, the branch AB takes the place of branch CD and the branch CD takes the position of the branch AB. Therefore, the induced current goes as D → C → B → A.



4.20 Electric generater

But, the branch BA is always in contact with the brush B_1 and branch DC in the contct with B_2. Hence, in the external circuit current flows from B_1 to B_2 i.e. opposite to the previous half rotation. This reapeats after every half rotation and alternating current is produced. This is what is called an AC generator .

What will be required to make a DC generator? The DC does not change the direction in the external circuit. To achieve this, a split ring is fixed on the axle like a split ring used in electric motor. Because of this arrangement, the branch of the coil going upwards is always in contact with one brush and the branch going downwards is always in contact with the other brush. Hence, the current flows in one direction in the external circuit. This is why this generator is called as a DC generator.

Use your brain power ! Draw the diagram of a DC generator. Then explain as to how the DC current is obtained .

Exercise

1. **Tell the odd one out. Give proper explanation.**
   a. Fuse wire, bad conductor, rubber gloves, generator.
   b. Voltmeter, Ammeter, galvanometer, thermometer.
   c. Loud speaker, microphone, electric motor, magnet.
2. **Explain the construction and working of the follwoing. Draw a neat diagram and label it.**
   a. Electric motor
   b. Electric Generator(AC)
3. **Electromagnetic induction means-**
   a. Charging of an electric conductor.
   b. Production of magnetic field due to a current flowing through a coil.
   c. Generation of a current in a coil due to relative motion between the coil and the magnet.
   d. Motion of the coil around the axle in an electric motor.
4. **Explain the difference : AC generator and DC generator.**
5. **Which device is used to produce electricity? Describe with a neat diagram.**
   a. Electric motor
   b. Galvanometer
   c. Electric Generator (DC)
   d. Voltmeter
6. **How does the short circuit form? What is its effect?**

Science I
Class 10
Page No. 62

5. Heat

- Latent heat
- Anomalous behaviour of water
- Specific heat capacity
- Regelation
- Dew point and humidity

Can you recall?

1. What is the difference between heat and temperature?
2. What are the different ways of heat transfer?

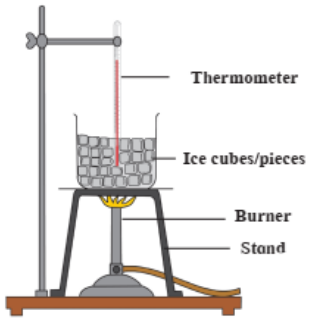
In the previous standard, we have learnt about heat and different types of heat transfer. We have also performed few experiments related to expansion and contraction of solids, liquids and gases. We have learnt about the difference between heat and temperature. We have also seen how temperature is measured using a thermometer.

Concepts like latent heat of phase transformation, anomalous behaviour of water, dew point, humidity, specific heat capacity etc are related to certain phenomena experienced by us in our day-to-day life. Let us learn more about these concepts.

Latent heat

Try this

1. Take a few pieces of ice in a glass beaker. As shown in figure 5.1.
2. Insert the bulb of a thermometer in ice and measure its temperature.
3. Put the beaker on a stand and heat the ice using a burner.
4. Record the temperature using the thermometer after every minute.
5. As the ice is heated, it starts melting. Stir the mixture of ice and water.
6. Continue the heating even after ice starts melting.
7. Draw a graph of temperature versus time.



5.1 Latent heat

You will observe that the temperature of the mixture remains 0 °C till the ice melts completely. If we continue heating, even after conversion of all the ice into water, the temperature of water starts rising and reaches 100 °C. At this temperature water starts converting into steam. The temperature of water remains constant at 100 °C till all water converts into steam. The graph of temperature versus time is shown in figure 5.2.

In this graph, line AB represents conversion of ice into water at constant temperature. When ice is heated it melts at 0 °C and converts into water at this constant temperature. The ice absorbs heat energy during this transition and the absorption of energy continues till all the ice converts into water.

Science I
Class 10
Page No. 67

The relative humidity at the dew point is 100%. If the relative humidity is more than 60% we feel that the air is humid. If the relative humidity is less than 60%, we feel that the air is dry.

During winter season, you may have observed a white trail at the back of a flying plane in a clear sky. As the plane flies, the vapor released by the aeroplane engine condenses and forms clouds. If the surrounding air is having more relative humidity, it takes a long time for the white trail, formed by condensation of the vapor, to disappear. If relative humidity of the surrounding air is less, either the size of the white trail may be small or it may not even get formed.

Try this.

1. Take a bottle of cold water out of a refrigerator and keep it outside for a while. Observe the outer surface of the bottle.
2. Drops of water can be observed on the outer surface of bottle. In the same way, if we observe the leaves of plants/grass or window-glass of a vehicle in the early morning we see water droplets collected on the surface.

Through these two observations, we sense the presence of water vapor in the atmosphere. When air cools, due to decrease in temperature it becomes saturated with water vapor. As a result, the excess water vapor gets converted into tiny droplets. The dew-point temperature is decided by the amount of vapor in the air.

Unit of heat

The units of heat are Joule (J) in SI units, cal (calorie) in cgs units.

The amount of heat necessary to raise temperature of 1 g of water by 1 °C from 14.5 °C to 15.5 °C is called one cal heat.

Similarly, the amount of heat necessary to raise the temperature of 1 kg of water by 1 °C from 14.5 °C to 15.5 °C is called one kcal heat.

It is clear that (1 kcal= 1000 cal).

Always remember

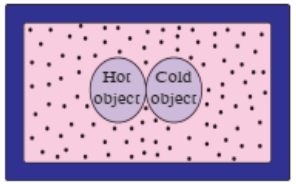
If we heat 1 kg of water by 1°C in different temperature range than 14.5 °C to 15.5 °C, the amount of heat required will be slightly different. It is, therefore, essential to define a specific temperature range while defining the unit of heat. Calorie and Joule are related by following relation: 1 cal = 4.18 Joule

Introduction to Scientist

James Prescot Joule (1818-1889) : He was the first person to show that the kinetic energy of tiny particles of matter appears as heat energy and also that energy can be converted from one form to another. Conversion of heat energy to work gives the first law of thermodynamics. The unit of heat is called Joule (J) after him.

Science I
Class 10
Page No. 69

Heat Exchange If heat is exchanged between a hot and cold object, the temperature of the cold object goes on increasing due to gain of energy and the temperature of the hot object goes on decreasing due to loss of energy. The change in temperature continues till the temperatures of both the objects attain the same value. In this process, the cold object gains heat energy and the hot object loses heat energy. If the system of both the objects is isolated from the environment by keeping it inside a heat resistant box (meaning that the energy exchange takes place between the two objects only), then no energy can flow from inside the box or come into the box (fig 5.10). In this situation, we get the following principle



5.10 Box of heat resistant material

Heat energy lost by the hot object = Heat energy gained by the cold object. This is called as 'Principle of heat exchange'

Measurement of specific heat: (mixing method) and calorimeter

The specific heat of an object can be measured using mixing method. For this calorimeter is used. You have learnt about calorimeter in the previous standard. If a hot solid object is put in the water in a calorimeter, heat exchange between the hot object and the water and calorimeter starts. This continues till the temperatures of the solid object, water and the calorimeter become equal. Therefore,

Heat lost by solid object = heat gained by water in calorimeter + heat gained by the calorimeter.

Here, heat lost by the solid object (Q) = mass of the solid object × its specific heat × decrease in its temperature.

Similarly,

Heat gained by the water (Q_1)= mass of the water × its specific heat × increase in its temperature

Heat gained by the calorimeter (Q_2)= mass of the calorimeter × its specific heat × increase in its temperature.

Heat lost by hot object = Heat gained by calorimeter + Heat gained by water.

$$Q = Q_2 + Q_1$$

Using these equations, if the specific heat of water and the calorimeter are known, the specific heat of the solid object can be calculated.

ICT :

Prepare a presentation using videos, pictures,audios, graphs etc. to explain various concepts in this chapter. Collect all such material from the Internet, using Information Technology. Under the guidance of your teachers, arrange a competition of such presentations in your class.

Solved Examples

Example 1: How much heat energy is necessary to raise the temperature of 5 kg of water from 20 °C to 100 °C.

Given: m= 5 kg, c = 1 kcal/kg °C and change in temperature ΔT = 100-20 = 80°C

Energy to be supplied to water = energy gained by water

= mass of water × specific heat of water × change in temperature of water

= m × c × ΔT

= 5 × 80 °C

= 400 kcal

Hence, the heat energy necessary to raise the temperature of water = 400 kcal.

Science I
Class 10
Page No. 70-71

Example 2: A copper sphere of 100 g mass is heated to raise its temperature to 100 °C and is released in water of mass 195 g and temperature 20 °C in a copper calorimeter. If the mass of calorimeter is 50 g, what will be the maximum temperature of water?

Given: Specific heat of copper = 0.1 cal/g °C

And so specific heat of calorimeter= 0.1 cal/ g °C

Suppose the copper ball water and the calorimeter attain final temperature T.

Heat lost by solid object = heat gained by water in calorimeter + heat gained by the calorimeter.

Here, heat lost by the copper ball = mass of the copper ×specific heat of copper × decrease in temperature of the ball

$Q = 100 \times 0.1 \times (100 - T)$

Similarly,

Heat gained by the water = mass of the water X its specific heat X increase in its temperature

$Q_1 = 195 \times 1 \times (T - 20)$ and

Heat gained by the calorimeter = mass of the calorimeter × its specific heat × increase in its temperature

$Q_2 = 50 \times 0.1 \times (T - 20)$

$Q = Q_1 + Q_2$

$100 \times 0.1 \times (100 - T) = 195 \times 1 \times (T - 20) + 50 \times 0.1 \times (T - 20)$

$10 (100 - T) = 195 (T - 20) + 5 (T - 20)$

$10 (100 - T) = 200 (T - 20)$

$210 T = 5000$

$T = 23.8$ °C

∴ The maximum temperature of water will be 23.8 °C.

Example 3: If 80 g steam of temperature 97 °C is released on an ice slab of temperature 0 °C, how much ice will melt? How much energy will be transferred to the ice when the steam will be transformed to water?

Given: Latent heat of melting the ice = L_{melt} = 80 cal/g

Latent heat of vaporization of water = $L_{vap.}$ = 540 cal/g

Solution: mass of steam = m_{steam} = 80 g

Temperature of steam = 97 °C

Temperature of ice = T_{ice} = 0 °C

Heat released during conversion of steam of temperature 97 °C into water of temperature 97 °C = $m_{steam} \times L_{vap.}$

= 80 X 540 ---------- (1)

Heat released during conversion of water of 97 °C into water at 0 °C

$= m_{steam} \times \Delta T \times c$

$= 80 \times (97 - 0) \times 1 = 80 \times 97$ ---------- (2)

Total heat gained by the ice 80 × 540 + 80 × 97 from equations (1) and (2)

= 80 (540 + 97)

= 80 × 637 = 50960 cal.

Some mass, of the ice m_{ice}, will melt due to this heat gained by the ice, then,

m_{ice} X L_{melt} = 50960 cal

m_{ice} X 80 = 50960

m_{ice} = 637 g

Thus, 637 g ice will melt and 50960 cal kcal will be given to the ice.

Books are My Friends : Read for more information

1. A Textbook of heat - J.B. Rajam
2. Heat - V.N Kelkar
3. A Treatise on Heat - Saha and Srivastava

Exercise

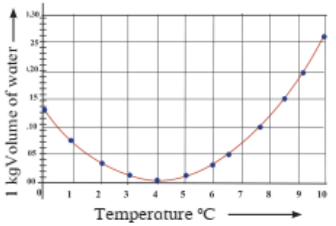
1. **Fill in the blanks and rewrite the sentence.**

a. The amount of water vapor in air is determined in terms of its .....

b. If objects of equal masses are given equal heat, their final temperature will be different. This is due to difference in their .....

c. During transformation of liquid phase to solid phase, the latent heat is .....

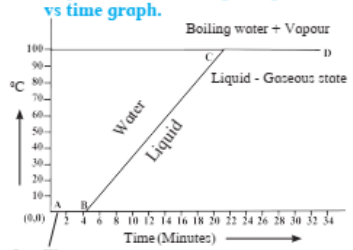
2. **Observe the following graph. Considering the change in volume of water as its temperature is raised from 0 °C, discuss the difference in the behaviour of water and other substances. What is this behaviour of water called?**



3. **What is meant by specific heat capacity? How will you prove experimentally that different substances have different specific heat capacities?**

4. **While deciding the unit for heat, which temperatures interval is chosen? Why?**

5. **Explain the following temperature vs time graph.**



6. **Explain the following:**

a. What is the role of anomalous behaviour of water in preserving aquatic life in regions of cold climate?

b. How can you relate the formation of water droplets on the outer surface of a bottle taken out of refrigerator with formation of dew?

c. In cold regions in winter, the rocks crack due to anomolous expansion of water.

Science I
Class 10
Page No. 73

6. Refraction of light

- Refraction of light
- Refractive index
- Laws of refraction
- Dispersion of light

Can you recall?

1. What is meant by reflection of light?
2. What are the laws of reflection?

We have seen that, generally light travels in a straight line. Because of this, if an opaque object lies in its path, a shadow of the object is formed. We have also seen in previous classes how these shadows change due to the change in relative positions of the source of light and the object. But light can bend under some special circumstances as we will see below

Refraction of light

Try this. **Material:** Glass, 5 rupee coin, Pencil, metallic vessel etc.

Activity 1:

1. Take a transparent glass and fill it with water.
2. Dip some portion of a pencil vertically in water and observe the thickness of the portion of the pencil, in water.
3. Now keep the pencil inclined to water surface and observe its thickness.

In both cases, the portion of the pencil inside water appears to be thicker than the portion above water. In the second case, the pencil appears to be broken near the surface of water. Why does it happen?

Activity 2:

1. Keep a 5 rupee coin in a metallic vessel.
2. Slowly go away from the vessel
3. Stop at the place when the coin disappears.
4. Keep looking in the direction of the coin.
5. Ask a friend to slowly fill water in the vessel. You will be able to see the coin once the level of water reaches a certain height. Why does it happen?

In both the above activities the observed effects are created due to the change in the direction of light while coming out of water. **Light changes its direction when going from one transparent medium to another transparent medium. This is called the refraction of light.**

Activity 3:

1. Keep a glass slab on a blank paper and draw its outline PQRS as shown in figure 6.1.
2. Draw an inclined straight line on the side of PQ so that it intersects PQ at N. Pierce two pins vertically at two points A and B along the line.
3. Look at the pins A and B from the opposite side of the slab and pierce pins C and D vertically so that the images of A and B are in line with C and D.
4. Now remove the slab and the pins and draw a straight line going through points C and D so that it intersects SR at M.
5. Join points M and N. Observe the incident ray AN and emergent ray MD.

ELITE Tutors

Science I
Class 10
Page No. 75

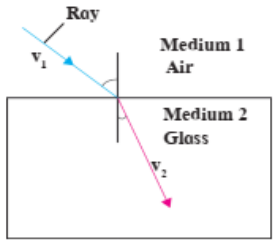
Substance	Refractive index	Substance	Refractive index	Substance	Refractive index
Air	1.0003	Fused Quartz	1.46	Carbon disulphide	1.63
Ice	1.31	Turpentine oil	1.47	Dense flint glass	1.66
Water	1.33	Benzene	1.50	Ruby	1.76
Alcohol	1.36	Crown glass	1.52	Sapphire	1.76
Kerosin	1.39	Rock salt	1.54	Diamond	2.42

Absolute refractive indices of some media

Let the velocity of light in medium 1 be v_1 and in medium 2 be v_2 as shown in figure 6.3. The refractive index of the second medium with respect to the first medium, ${}_2n_1$ is equal to the ratio of the velocity of light in medium 1 to that in medium 2.

$$\text{Refractive index } {}_2n_1 = \frac{\text{Velocity of light in medium 1 } (v_1)}{\text{Velocity of light in medium 2 } (v_2)}$$

Similarly, the refractive index of medium 1 with respect to medium 2 is



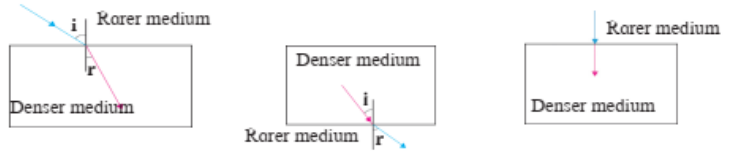
6.3 Light ray going from medium 1 to medium 2

$${}_1n_2 = \frac{v_2}{v_1}$$

If the first medium is vacuum then the refractive index of medium 2 is called absolute refractive index and it is written as n.

Can you tell?

If the refractive index of second medium with respect to first medium is ${}_2n_1$ and that of third medium with respect to second medium is ${}_3n_2$, what and how much is ${}_3n_1$?



6.4 Refraction of light in different media

When a light ray passes from a rarer medium to a denser a medium, it bends towards the normal.

When a light ray passes from a denser medium to a rarer medium, it bends away from the normal.

When a light ray is incident normally at the boundary between two media, it does not change its direction and hence does not get refracted.

Science I
Class 10
Page No. 76

Twinkling of stars

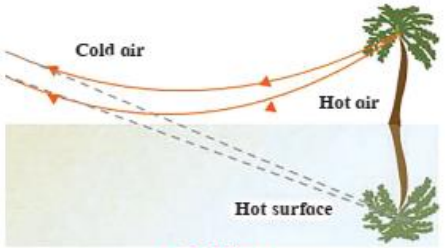
Can you tell?

1. Have you seen a mirage which is an illusion of the appearance of water on a hot road or in a desert?
2. Have you seen that objects beyond and above a holi fire appear to be shaking? Why does this happen?

Local atmospheric conditions affect the refraction of light to some extent. In both the examples above, the air near the hot road or desert surface and near the holi flames is hot and hence rarer than the air above it. The refractive index of air keeps increasing as we go to increasing heights. In the first case above, the direction of light rays, coming from a distance, keeps changing according to the laws of refraction.

The light rays coming from a distant object appear to be coming from the image of the object inside the ground as shown in figure 6.5. This is called a mirage.

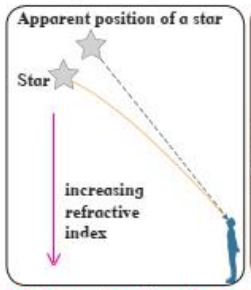
In the second example, the direction of light rays coming from objects beyond the holi fire changes due to changing refractive index above the fire. Thus, the objects appear to be moving.



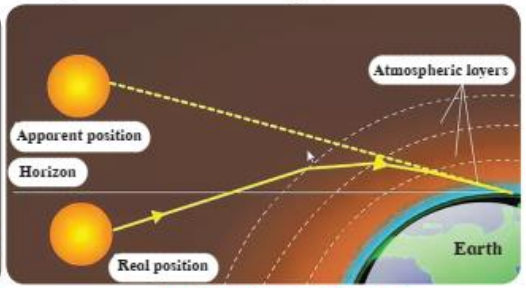
6.5 Mirage

Effect of atmospheric conditions on refraction of light can be seen in the twinkling of the stars.

Stars are self luminous and can be seen at night in the absence of sunlight. They appear to be point sources because of their being at a very large distance from us. As the desity of air increases with lowering height above the surface of the earth, the refractive index also increases. Star light coming towards us travels from rarer medium to denser medium and constantly bends towards the normal. This makes the star appear to be higher in the sky as compared to its actual position as shown in the figure, 6.6.



6.6 Apparent position of a star



6.7 Effect of atmospheric refraction

The apparent position of the star keeps changing a bit. This is because of the motion of atmospheric air and changing air density and temperature. Because of this, the refractive index of air keeps changing continuously. Because of this change, the position and brightness of the star keep changing continuously and the star appears to be twinkling.

Science I
Class 10
Page No. 77

We do not see twinkling of planets. This is because, planets are much closer to us as compared to stars. They, therefore, do not appear as point sources but appear as a collection of point sources. Because of changes in atmospheric refractive index the position as well as the brightness of individual point source change but the average position and total average brightness remains unchanged and planets do not twinkle.

By Sunrise we mean the appearance of the Sun above the horizon. But when the Sun is somewhat below the horizon, its light rays are able to reach us along a curved path due to their refraction through earth's atmosphere as shown in the figure 6.7. Thus, we see the Sun even before it emerges above the horizon. Same thing happens at the time of Sunset and we keep seeing the Sun for a short while even after it goes below the horizon.

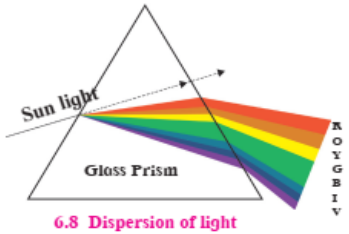
Dispersion of light

Hold the plastic scale in your compass in front of your eyes and see through it while turning it slowly. You will see light rays divided into different colours. These colours appear in the following order: violet, indigo, blue, green, yellow, orange and red. You know that light is electromagnetic radiation. Wavelength is an important property of radiation. The wavelength of radiation to which our eyes are sensitive is between 400 and 700 nm. In this interval, radiation of different wavelengths appears to have different colours mentioned above. The red light has maximum wavelength i.e. close to 700 nm while violet light has the smallest wavelength, close to 400 nm. Remember that 1 nm = 10^{-9} m.

In vacuum, the velocity of light rays of all frequencies is the same. But the velocity of light in a medium depends on the frequency of light and thus different colours travel with different velocity. Therefore, the refractive index of a medium is different for different colours. Thus, even when white light enters a single medium like glass, the angles of refraction are different for different colours. So when the white light coming from the Sun through air, enters any refracting medium, it emerges as a spectrum of seven colours.

The process of separation of light into its component colours while passing through a medium is called the dispersion of light.

Sir Issac Newton was the first person to use a glass prism to obtain Sun's spectrum. When white light is incident on the prism, different colours bend through different angles. Among the seven colours, red bends the least while violet bends the most. Thus, as shown in figure 6.8, the seven colours emerge along different paths and get separated and we get a spectrum of seven colours.



6.8 Dispersion of light

Use your brain power !

1. From incident white light how will you obtain white emergent light by making use of two prisms?

2. You must have seen chandeliers having glass prisms. The light from a tungsten bulb gets dispersed while passing through these prisms and we see coloured spectrum. If we use an LED light instead of a tungsten bulb, will we be able to see the same effect?

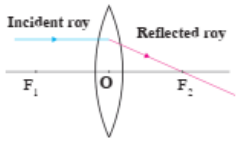
Science I
Class 10
Page No. 82

What is this distance between the lens and the screen called? Discuss the relation What is the distance between this distance and the radius of curvature of the lens with your teacher. The image of a distant object is obtained close to the focus of the lens, hence, the above distance is the focal length of the lens. What will happen if you use a concave lens in this experiment?

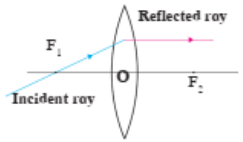
Ray diagram for refraction : You have learnt the rules for drawing ray diagrams for spherical mirrors. Similarly, one can obtain the images formed by lenses with the help of ray diagrams. One can obtain the position, size and nature of the images with the help of these diagrams.

Images formed by convex lenses

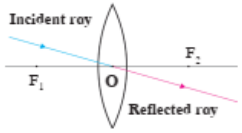
One can use following three rules to draw ray diagrams of images obtained by convex lenses.



Rule 1: When the incident ray is parallel to the principal axis, the refracted ray passes through the principal focus.



Rule 2: When the incident ray passes through the principal focus, the refracted ray is parallel to the principal axis.



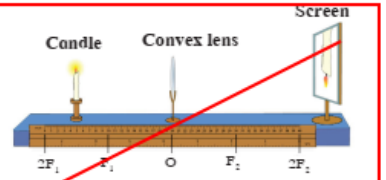
Rule 3: When the incident ray passes through the optical centre of the lens, it passes without changing its direction.

Try This

Material: A convex lens, screen, meter scale, stand for the lens, chalk, candle etc

Method:

1. Draw a straight line along the centre of a long table.
2. Place the lens on the stand at the central point (O) of the line.
3. Place the screen on one side, of the lens. Move it along the line so as to get a clear image of a distant object. Mark its position as F_1.
4. Measure the distance between O and F_1. Mark a point at distance $2F_1$ from O on the same side of F_1 and mark it as $2F_1$.



7. 6 Arrangement for the experiment

5. Repeat actions 3 and 4 on the other side of the lens and mark F_2 and $2F_2$ on the straight line.
6. Now place the burning candle on the other side of lens far beyond $2F_2$. Place the screen on the opposite side of the lens and obtain a clear image of the candle by moving it forward or backward along the line. Note the position, size and nature of the image.
7. Repeat action 6 by placing the candle beyond $2F_1$, at $2F_1$, between $2F_1$ and F_1, at F_1 and between F_1 and O. Note your observations.

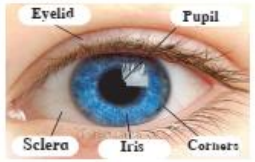
Can you recall?

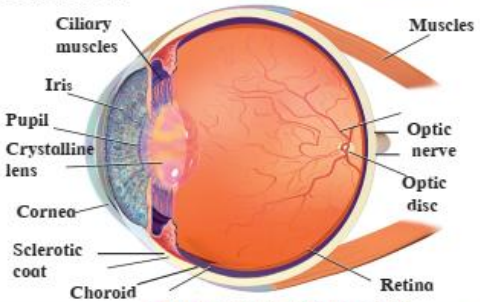
What are real and virtual images? How will you find out whether an image is real or virtual? Can a virtual image be obtained on a screen?

Science I
Class 10
Page No. 87

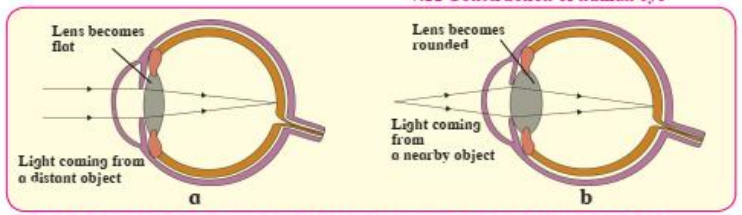
While seeing objects at large, infinite distances, the lens of the eye becomes flat and its focal length increases as shown in part a of the figure 7.12. While seeing nearby objects the lens becomes more rounded and its focal length decreases as shown in part b of the figure 7.12. This way we can see objects clearly irrespective of their distance.

The capacity of the lens to change its focal length as per need is called its power of accommodation. Although the elastic lens can change its focal length, to increase or decrease it, it can not do so beyond a limit.





7.11 Construction of human eye



7.12 The change in the shape of the lens while seeing distant and nearby objects.

The minimum distance of an object from a normal eye, at which it is clearly visible without stress on the eye, is called as minimum distance of distinct vision. The position of the object at this distance is called the near point of the eye, for a normal human eye, the near point is at 25 cm. The farthest distance of an object from a human eye, at which it is clearly visible without stress on the eye is called farthest diastance of distinct vision. The position of the object at this distance is called the far point of the eye. For a normal human eye, the far point is at infinity.

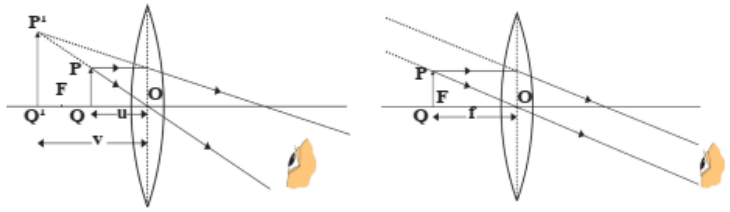
Do you know ?

The eye ball is approximately sperical and has a diameter of about 2.4 cm. The working of the lens in human eye is extremely important. The lens can change its focal length to adjust and see objects at different distances. In a relaxed state, the focal length of healthy eyes is 2 cm. The other focus of the eye is on the retina.

Science I
Class 10
Page No. 90

Use of convex lenses

a. Simple microscope : A convex lens with small focal length produces a virtual, erect and bigger image of an object as shown in the figure. Such a lens is called simple microscope or magnifying lens. One can get a 20 times larger image of an object using such microscopes. These are used for watch repair, testing precious gems and finding their defects.

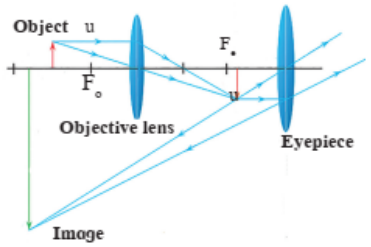


a. Object is close to the lens b. Object is at the focus

7.16 Simple microscope

b. Compound microscope

Simple microscope is used to observe small sized objects. But minute objects like blood cells, cells of plants and animals and minute living beings like bacteria cannot be magnified sufficiently by simple microscope. Compound microscopes are used to study these objects. A compound microscope is made of two convex lenses: objective and eye piece. The objective has smaller cross-section and smaller focal length. The eye piece has bigger cross-section, its focal length is also larger than that of the objective. Higher magnification can be obtained by the combined effect of the two lenses.



7.17 A compound microscope

As shown in the figure 7.17, the magnification occurs in two stages. The image formed by the first lens acts as the object for the second lens. The axes of both lenses are along the same line. The lenses are fitted inside a metallic tube in such a way that the distance between can be changed.

c. Telescope

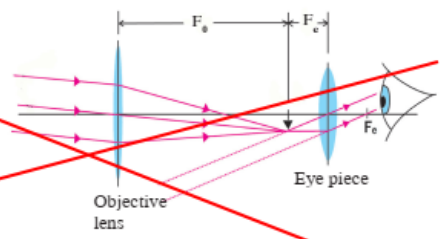
Telescope is used to see distant objects clearly in their magnified form. The telescopes used to observe astronomical sources like the stars and the planets are called astronomical telescopes. Telescopes are of two types.

1. Refracting telescope – This uses lenses
2. Reflecting telescope – This uses mirrors and also lenses.

In both of these, the image formed by the objective acts as object for the eye piece which forms the final image. Objective lens has large diameter and larger focal length because of which maximum amount of light coming from the distant object can be collected.

Science I
Class 10
Page No. 91

On the other hand the size of the eyepiece is smaller and its focal length is also less. Both the lenses are fitted inside a metallic tube in such a way that the distance between them can be changed. The principal axes of both the lenses are along the same straight line. Generally, using the same objective but different eye pieces, different magnification can be obtained.



7.18 Refracting telescope

d. Optical instrument

Convex lenses are used in various other optical instruments like camera, projector, spectrograph etc.

e. Spectacles

Convex lenses are used in spectacles for correcting farsightness .

Try this.

1. Take a burning incense stick in your hand and rotate it fast along a circle.
2. Draw a cage on one side of a cardboard and a bird on the other side. Hang the cardboard with the help of a thread. Twist the thread and leave it. What do you see and why?

Persistence of vision

We see an object because the eye lens creates its image on the retina. The image is on the retina as long as the object is in front of us. The image disappears as soon as the object is taken away. However, this is not instantaneous and the image remains imprinted on our retina for 1/16th of a second after the object is removed. The sensation on retina persists for a while.This is called persistence of vision. What examples in day to day life can you think about this?

Can you tell? How do we perceive different colours?

The retina in our eyes is made up of many light sensitive cells. These cells are shaped like a rod and like a cone. The rod like cells respond to the intensity of light and give information about the brightness or dimness of the object to the brain. The conical cells respond to the colour and give information about the colour of the object to the brain. Brain processes all the information received and we see the actual image of the object. Rod like cells respond to faint light also but conical cells do not. Thus we perceive colours only in bright light. The conical cells can respond differently to red, green and blue colours. When red colour falls on the eyes, the cells responding to red light get excited more than those responding to other colours and we get the sensation of red colour. Some people lack conical cells responding to certain colours. These persons cannot recognize those colours or cannot distinguish between different colours. These persons are said to be colour blind. Apart from not being able to distinguish between different colours, their eye sight is normal.

Science I
Class 10
Page No. 93

8. Metallurgy

- Physical properties of metals
- Chemical properties of metals
- Chemical properties of nonmetals
- Metallurgy: Various concepts.
- Physical properties of nonmetals
- Reactivity series of metals
- Ionic compounds.

Earth was born about 4.5 billion years ago. Various formative processes have been taking place in the core of the earth and its surroundings since its creation till today. These have resulted in the formation of various ores, liquids and gases.

Think about it Which method do we use when we want to study many things together and at the same time?

The substances around us are in the form of some or the other elements or their compounds. In the beginning, elements were classified in accordance with their chemical and physical properties into the types metals, nonmetals and metalloids, and these are in use even today. You have studied their characteristics in the last standard. We are going to get more information about them in this lesson.

Can you tell? What are the physical properties of metals and nonmetals?

Physical properties of metals

Metals exist mainly in solid state. The metals namely, mercury and gallium exist in liquid state at room temperature. Metals possess luster. The metallic luster goes on decreasing due to exposure to atmospheric oxygen and moisture and also in presence of some reactive gases.

We know that metals have the properties namely, ductility and malleability. Similarly, all metals are good conductors of heat and electricity. Generally, all metals are hard. However, the alkali metals from group 1 such as lithium, sodium and potassium are exceptions. These metals can be cut with knife as they are very soft. Metals have high melting and boiling points. For example, tungsten metal has the highest melting point (3422 °C). On the contrary, the melting and boiling points of the metals such as sodium, potassium, mercury, galium are very low. A sound is produced when certain metals are struck. This is called sonority. These metals are known as sonorous metals.

Physical properties of nonmetals

When properties of nonmetals are considered, it is found that some nonmetals are in solid state while some are in gaseous state. Exception is the nonmetal bromine which exists in liquid state. Nonmetals do not posses luster, but iodine is the exception as its crystals are shiny. Nonmetals are not hard. Diamond which as an allotrope of carbon is the exception. Diamond is the hardest natural substance. Nonmetals have low melting and boiling points. Nonmetals are bad conductors of electricity and heat. Graphite, an allotrope of carbon, is an exception, as it is a good conductor of electricity.

ELITE Tutors

Science I
Class 10
Page No. 94

Chemical properties of metals

Metals are reactive. They lose electrons easily and become positively charged ions. That is why metals are called electropositive elements.

Do you know ?

Substances which are good conductors of heat are usually good conductors of electricity as well. Similarly bad conductors of heat are also bad conductors of electricity. The exception is diamond which is bad conductor of electricity but good conductor of heat.

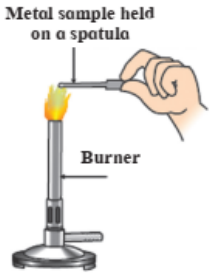
Try this.

Apparatus : Pair of tongs or spatula, knife, burner, etc.

Chemicals : Samples of aluminium, copper, iron, lead, magnesium, zinc and sodium.
(Note: Use sodium carefully, in presence of teacher)

Procedure : Hold the sample of each of the above metals at the top of the flame of a burner with the help of a pair of tongs, or a spatula.

1. Which metal catches fire readily?
2. How does the surface of a metal appear on catching fire?
3. What is the colour of the flame while the metal is burning on the flame?



8.1 Combustion of metal

Reactions of Metals:

a. Reaction of metals with oxygen

Metals combine with oxygen on heating in air and metal oxides are formed. Sodium and potassium are very reactive metals. Sodium metal combines with oxygen in the air even at room temperature and forms sodium oxide.

$$4Na(s) + O_2(g) \longrightarrow 2Na_2O(s)$$

On exposure to air sodium readily catches fire. Therefore, to prevent accident in the laboratory or elsewhere it is kept in kerosene. Oxides of some metals are soluble in water. They react with water to form alkali.

$$Na_2O(s) + H_2O(l) \longrightarrow 2NaOH(aq)$$

We know that magnesium oxide is formed on burning magnesium ribbon in the air. Magnesium oxide reacts with water to form an alkali, called magnesium hydroxide.

$$2Mg(s) + O_2(g) \longrightarrow 2\,MgO(s)$$

$$MgO + H_2O \longrightarrow Mg(OH)_2$$

b. Reaction of metals with water

Apparatus : Beakers.

Chemicals : Samples of various metals (Important note : Sodium metal should not be taken), water.

Procedure : Drop a piece of each of the metal in separate beakers filled with cold water.

1. Which metal reacts with water?
2. Which metal floats on water? Why? Prepare a table with reference to the above procedure and note your observations in it.

Science I
Class 10
Page No. 95

Sodium and potassium metal react rapidly and vigorously with water and liberates hydrogen gas.

$2Na(s) + 2H_2O(l) \longrightarrow 2NaOH(aq) + H_2(g) + heat$

$2K(s) + 2H_2O(l) \longrightarrow 2KOH(aq) + H_2(g) + heat$

On the other hand, calcium reacts with water slowly and less vigorously. The hydrogen gas released in this reaction collects on the surface of the metal in the form of bubbles and the metal floats on water.

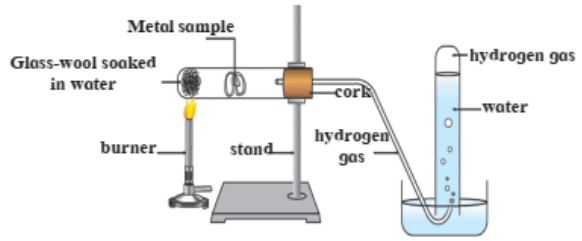
$2Ca(s) + 2H_2O(l) \longrightarrow 2Ca(OH)_2(aq) + H_2(g)$

The metals; aluminium, iron and zinc do not react with cold or hot water, but they react with steam to form their oxides. Hydrogen gas is released in this reaction.

$2Al(s) + 3H_2O(g) \longrightarrow Al_2O_3(s) + 3H_2(g)$

$3Fe(s) + 4H_2O(g) \longrightarrow Fe_3O_4(s) + 4H_2(g)$

$Zn(s) + H_2O(g) \longrightarrow ZnO(s) + H_2(g)$



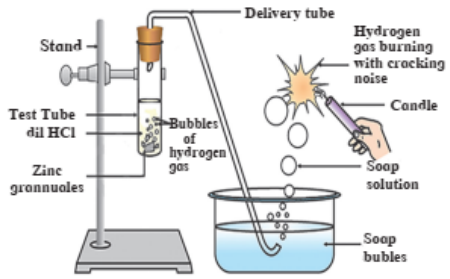
8.2 Reaction of a metal with water

Try out and think about it Test whether the metals gold, silver and copper react with water and think over the finding.

c. Reaction of metals with oxygen

In the earlier chapter we have looked into reaction of metals with acids. Are all the metals equally reactive?
When samples of aluminium, magnesium, iron or zinc are treated with dilute sulphuric or hydrochloric acid, sulphate or chloride salts of metals are formed. Hydrogen gas is liberated in this reaction. The reactivity of these metals can be indicated by the following sequence.

Mg > Al > Zn > Fe



8.3 Reaction of metals with dilute acid

ELITE Tutors

Science I
Class 10
Page No. 96

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

$2Al(s) + 6HCl(aq) \longrightarrow 2AlCl_3(aq) + 3H_2(g)$

$Fe(s) + 2HCl(aq) \longrightarrow FeCl_2(aq) + H_2(g)$

$Zn(s) + HCl(aq) \longrightarrow ZnCl_2(aq) + H_2(g)$

d. Reaction of metals with nitric acid

Nitrate salts of metals are formed on reaction of metals with nitric acid. Various oxides of nitrogen (N_2O, NO, NO_2) are also formed in accordance with the concentration of nitric acid.

$Cu(s) + 4\,HNO_3(aq) \longrightarrow Cu(NO_3)_2(aq) + 2NO_2(g) + 2H_2O(l)$
(Concentrated)

$3\,Cu(s) + 8HNO_3(aq) \longrightarrow Cu(NO_3)_2(aq) + 2NO(g) + 4H_2O(l)$
(Dilute)

Aqua Regia: Aqua regia is a highly corrosive and fuming liquid. It is one of the few reagents which can dissolve the noble metals like gold and platinum. Aqua regia is freshly prepared by mixing concentrated hydrochloric acid and concentrated nitric acid in the ratio 3:1.

e. Reaction of metals with salts of other metals

Try this.

Apparatus: Copper wire, iron nail, beaker or big test tube etc.
Chemicals: Aqueous solutions of ferrous sulphate and copper sulphate.

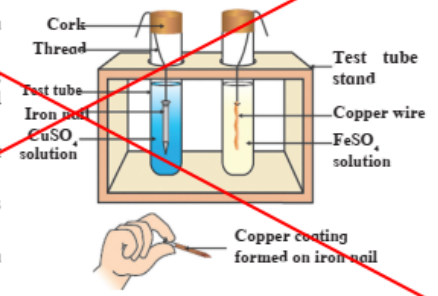
Procedure:

1. Take a clean copper wire and a clean iron nail.
2. Dip the copper wire in ferrous sulphate solution and the iron nail in copper sulphate solution.
3. Keep on observing continually at a fixed interval of time.

a. In which test tube a reaction has taken place?

b. How did you recognize that a reaction has taken place?

c. What is the type of the reaction?



8.4 Reaction of metal with solution of salts of other metals

Reactivity series of metals

We have seen that reactivity of all metals is not the same. However, the reagents oxygen, water and acids are not useful to determine the relative reactivities of all the metals, as all the metals do not react with them. The displacement reaction of metals with solutions of salts of other metals serves this purpose. If a metal A displaces another metal B from the solution of its salt then it means that the metal A is more reactive than the metal B.

ELITE Tutors

Science I
Class 10
Page No. 98

2. Reaction of nonmetals with water : Generally, nonmetals do not react with water, except the halogens. For example, chlorine on dissolving in water gives the following reaction.

$$Cl_2(g) + H_2O(l) \longrightarrow HOCl(aq) + HCl(aq)$$

3. Reaction of dilute acids with nonmetals : Generally, nonmetals do not react with dilute acids, halogens are exception to this. For example, chlorine reacts with dilute hydrobromic acid by the following reaction.

$$Cl_2(g) + 2HBr(aq) \longrightarrow 2HCl(aq) + Br_2(aq)$$

4. Reaction of nonmetals with hydrogen :

Nonmetals react with hydrogen under certain condition (such as proper temperature, pressure, use of catalyst, etc.)

$$S + H_2 \longrightarrow H_2S$$

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

Use your brain power ! In the reaction between chlorine and HBr a transformation of HBr into Br_2 takes place. Can this transformation be called oxidation? Which is the oxidant that brings about this oxidation?

Ionic compounds

The compounds formed from two units, namely cation and anion are called ionic compounds. The cation and anion being oppositely charged, there is an electrostatic force of attraction between them. You know that, this force of attraction between cation and anion is called as the ionic bond. The number of cations and anion in a compound and the magnitude of the electric charge on them is such that the positive and negative charges balance each other. As a result, an ionic compound is electrically neutral.

Ionic compounds are crystalline in nature. The surfaces of all the particles of a crystalline substance have a definite shape and are smooth and shiny. The regular arrangement of ions in the solid ionic compounds is responsible for their crystalline nature. The arrangement of ions is different in different ionic compounds, and therefore the shapes of their crystals are different. The main factor that determines the general arrangement of ions in a crystal is the attractive force between oppositely charged ions and the repulsive force between similarly charged ions. Because of this the general crystalline structure has negative ions arranged around a positive ion and positive ions arranged around a negative ion. Two of the important factors responsible for a certain crystal structure are as follows.

1) Size of the positively and negatively charged ions.
2) Magnitude of the electrical charge on the ions.

The electrostatic attraction in the neighbouring ions with opposite charges is very strong. That is why the melting points of ionic compounds are high. Also, the ionic compounds are hard and brittle.

Properties of ionic compounds

Try this.

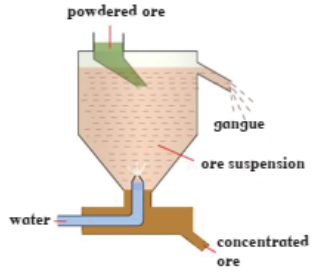
Apparatus: Metal spatula, burner, carbon electrodes, beaker, cell, lamp, press key, electrical wires, etc.

Chemicals: Samples of sodium chloride, potassium iodide and barium chloride, water.

Procedure: Observe the above samples. Place sample of one of the above salts on the spatula and heat it on flame of the burner. Repeat the procedure using the other salts. As shown in the figure, assemble an electrolyte cell. Assemble an electrolytic cell by using a beaker and connecting the carbon electrodes to the positive and negative terminal of the cell. Dip the electrodes in solution of any one of the salts. Do you see the lamp glowing? Check this with all the other salts as well.

Science I
Class 10
Page No. 101

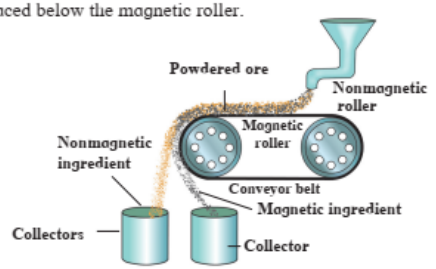
Finely ground ore is released in the tank. A forceful jel of water is introduced in the tank from the lower side. Gangue particles are lighter and therefore they flow out along with the water jet from the outlet on the upper side of the tank and get collected separately. At the same time the heavy particles of the ore are collected at the bottom from the lower side of the tank. In short, this method is based on the law of gravitation, wherein particles of the same size are separated by their weight with the help of water.



8.9 Hydraulic separation

b. Magnetic separation Method : This method requires an electromagnetic machine. The main parts of this machine are two types of iron rollers and the conveyor belt moving continuously around them. One of the rollers is nonmagnetic while the other is electromagnetic. The conveyor belt moving around the rollers is (nonmagnetic) made up of leather or brass. The powdered ore is poured on the conveyor belt near the nonmagnetic roller. Two collector vessels are placed below the magnetic roller.

The particles of the nonmagnetic part in the ore are not attracted towards the magnetic roller. Therefore, they are carried further along the belt and fall in the collector vessel places is away from the magnetic roller. At the same time the particles of the magnetic ingredients of the ore stick to the magnetic roller and therefore fall in the collector vessel near the magnetic roller.



8.10 Magnetic separation

In this way the magnetic and nonmagnetic ingredients in the ore can be separated depending on their magnetic nature. For example, cassiterite is a tin ore. It contains mainly the nonmagnetic ingredient stannic oxide (SnO_2) and the magnetic ingredient ferrous tungstate ($FeWO_4$). These are separated by the electromagnetic method.

c. Froth floatation method

The froth floatation method is based on the two opposite properties, hydrophilic and hydrophobic, of the particles. Here the particles of the metal sulphides, due to their hydrophobic property, get wetted mainly with oil, while due to the hydrophilic property the gangue particles get wetted with water. By using these properties certain ores are concentrated by froth floatation method.

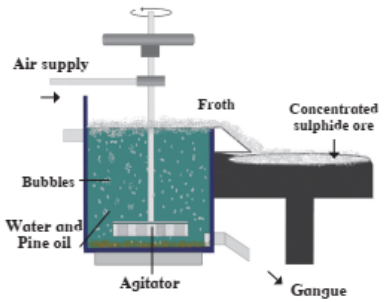
Internet my friend

Collect the information about the different steps of metal extraction & explain it in the class.

Collect the related videos.

Science I
Class 10
Page No. 102

In this method the finely ground ore is put into a big tank containing ample amount of water. Certain vegetable oil such as pine oil eucalyptus oil, is added in the water for the formation of froth. Pressurised air is blown through the water. There is an agitator rotating around its axis in the centre of the floatation tank. The agitator is used as per the requirement. Bubbles are formed due to the blown air. Due to agitation a foam is formed from oil, water and air bubbles together, due to the agitating. This foam rises to the surface of water and floats. That is why this method is called froth floatation process.



8.11 Froth floatation method

Particles of certain sulphide ore float with the foam on water as they preferencially get wetted by the oil. For example, this method is used for the concentration of zinc blend (ZnS) and copper pyrite ($CuFeS_2$)

d. Leaching

The first step in the extraction of the metals aluminium, gold and silver from their ores is the method of leaching. In this method the ore is soaked in a certain solution for a long time. The ore dissolves in that solution due to a specific chemical reaction. The gangue, however, does not react and therefore does not dissolve in that solution. So it can be separated. For example, concentration of bauxite, the aluminium ore, is done by leaching method. Here bauxite is soaked in aqueous NaOH or aqueous Na_2CO_3 which dissolves the main ingredient alumina in it.

Do you know ?

Water does not stick to colocasia leaves. Similarly, water does not stick to wax. On the other hand common salt or soap stick to water that is, they get wetted by water.

Can you recall? What is the electronic defination of oxidation and reduction?

During the extraction of metals from their ores, metal is obtained from the cation of metal. In this process the metal cation is to be reduced. How to bring about the reduction depends upon the reactivity of the metal. We have already learnt about the reactivity series of metals.

2. Extraction of metals

a. Extraction of reactive metals

The metals at the top of the reactivity series are highly reactive. Their reactivity decreases down the series. For example, potassium, sodium, aluminium are reactive metals. Reactive metals have large capacity to form cations by losing the electrons in their outermost shell. For example, reactive metals react vigorously with dilute acids to give hydrogen gas. Highly reactive metals burn by reacting with oxygen from air at room temperature. Their extraction has to be done by electrolytic reduction. For example, the metals sodium, calcium and magnesium are obtained by electrolysis of their molten chloride salts. In this process metal is deposited on the cathode while chlorine gas is liberated at the anode. The electrode reactions during the electrolysis of molten sodium chloride to get metallic sodium are as shown below.

Science I
Class 10
Page No. 105

The zinc oxide so obtained is reduced to zinc by using suitable reductant such as carbon.

$ZnO + C \longrightarrow Zn + CO\uparrow$

Apart from carbon, reactive metals such as sodium, calcium, aluminium are also used as reducing agent for the reduction of metal oxide to obtain the metal. This is because these metals displace a moderately reactive metal from its compound. For example, when manganese dioxide is ignited with aluminium powder the following reaction takes place.

$3\,MnO_2 + 4\,Al \longrightarrow 3Mn + 2Al_2O_3 + heat$

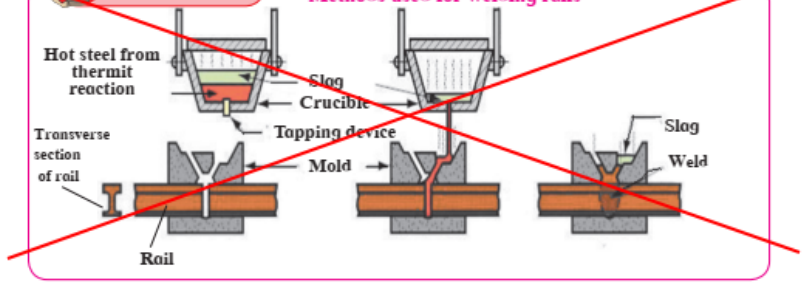
Identify the substances undergone oxidation and reduction in this reaction.

The heat evolved in the above reaction is so large that the metal is formed in the molten state. Another similar example is the thermit reaction. Here, iron oxide reacts with aluminium to form iron and aluminium oxide.

$Fe_2O_3 + 2\,Al \longrightarrow 2\,Fe + Al_2O_3 + heat$

Do you know ?

Methods used for welding rails



8.13 Thermit Welding

c. Extraction of less reactive metals

The metals at the bottom of the reactivity series of metals are less reactive. That is why they are found in free state in nature. For example gold, silver, platinum. The reserves of copper in free state are very few. Presently copper is found mainly in the form of Cu_2S.

Copper is obtained from Cu_2S ore just by heating in air.

$2Cu_2S + 3O_2 \longrightarrow 2\,Cu_2O + 2SO_2\uparrow$

$2\,Cu_2O + Cu_2S \longrightarrow 6Cu + SO_2\uparrow$

Collect information

Collect the information regarding how mercury is extracted from its ore cinnabar and write the corresponding chemical reaction.

3. Refining of metals

Metals obtained by the various reduction processes discribed above are not very pure. They contain impurities. The impurities need to be separated to obtain pure metal. Electrolysis method is used to obtain pure metals from impure metals.

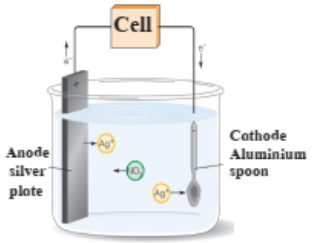
Science I
Class 10
Page No. 108

4. Electroplating

In this method a less reactive metal is coated on a more reactive metal by electrolysis. Silver plated spoons, gold plated ornaments are the examples of electroplating.

5. Alloying

Majority of the metallic substances used presently are in the form of alloys. The main intention behind this is to decrease the intensity of corrosion of metals. The homogenous mixture formed by mixing a metal with other metals or nonmetals in certain proportion is called an alloy. For example, bronze is an alloy formed from 90% copper and 10 % tin. Bronze statues do not get affected by sun and rain. Stainless steel does not get stains with air or water and also does not rust. It is an alloy made from 74% iron, 18% chromium and 8% carbon. In recent times various types of alloys are used for minting coins.



8.17 Electroplating

8.18 Coins made from various alloys

Do you know ?

When one of the metals in an alloy is mercury the alloy is called amalgam. For example, sodium amalgam, zinc amalgam, etc. Silver amalgam was earlier used by dentists. Gold amalgam is used for extraction of gold.

Collect information

1. What are the various alloys used in daily life? Where are those used?
2. What are the properties that the alloy used for minting coins should have?

Exercise

1. Write names.
   a. Alloy of sodium with mercury.
   b. Molecular formula of the common ore of aluminium.
   c. The oxide that forms salt and water by reacting with both acid and base.
   d. The device used for grinding an ore.
   e. The nonmetal having electrical conductivity.
   f. The reagent that dissolves noble metals.

2. Make pairs of substances and their properties

Substance	Property
a. Potassium bromide	1.Combustible
b. Gold	2.Soluble in water
c. Sulphur	3.No chemical reaction
d. Neon	4.High ductility.

Science I
Class 10
Page No. 110

9. Carbon Compounds

- Bonds in carbon compounds
- Hydrocarbons, Functional Groups and homologous series
- Chemical Properties of Carbon Compounds
- Carbon : A Versatile Element
- Nomenclature of Carbon compounds
- Macromolecules and Polymers

Can you recall?

1. What are the types of compounds ?
2. Objects in everyday use such as foodstuff, fibers, paper, medicines, wood, fuels, are made of various compounds. Which consituent elements are common in these compounds?
3. To which group in the periodic table does the element carbon belongs ? Write down the electronic configuration of carbon and deduce the valency of carbon.

In the previous standards we have seen that organic and inorganic compounds are the two important types of compounds. Except materials fabricated from metal and glass/soil several other materials from foodstuff to fuels are made up of organic compounds. The essential element in all the organic compounds is carbon. About 200 years back it was believed that organic compounds are obtained directly or indirectly from the organisms. However, after synthesis of the organic compound urea from an irganic compounds in the laboratory, the organic compounds received a new identity as carbon compounds. All the compounds having carbon as a constituent element are called as organic compounds. The compounds carbon dioxide, carbon monoxide, carbide salts, carbonate salts and bicarbonate salts are exception; they are inorganic compounds of carbon.

Bonds in Carbon compounds

You have learnt about the ionic compounds in the previous chapter. You have seen that ionic compounds have high melting and boiling points and they conduct electricity in the molten and dissolved state. You have also seen that these properties of ionic compounds are explained on the basis of the ionic bonds in them. The table 9.1 shows melting and boiling points of a few carbon compounds. Are these values higher or lower as compared to the ionic compounds?

Generally the melting and boiling points of carbon compounds are found to be lower than 300 °C. From this we understood that the intermolecular attractive forces are weak in carbon compounds.

In the previous stanadard on testing the electrical conductivity of carbon compounds, glucose and urea you have observed that they are not electrical condutors. Generally most of the carbon compounds are found to be bad conductors of electricity. From it we understand that structures of most of the carbon compounds lack ionic bonds. It means that the chemical bonds in carbon compounds do not produce ions.

Compound	Melting point °C	Boiling point °C
Methane (CH_4)	- 183	- 162
Ethanol (CH_2CH_2OH)	- 117	78
Chloroform ($CHCl_3$)	- 64	61
Acetic acid (CH_3COOH)	17	118

9.1 Melting and Boiling Points of a few carbon compounds

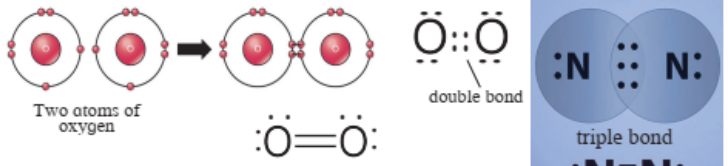
Can you tell?

1. What is meant by a chemical bond?
2. What is the number of chemical bonds that an atom of an element forms called?
3. What are the two important types of chemical bonds?

Science I
Class 10
Page No. 112

Let us first look at the hydrogen molecule which is the simplest example of a molecule formed by covalent bonding. You have already learnt that the atomic number of hydrogen being 1, its atom contains 1 electron in K shell. It requires one more electron to complete the K shell and attain the configuration of helium (He). To meet this requirement two hydrogen atoms share their electrons with each other to form H_2 molecule. One covalent bond, that is a single bond is formed between two hydrogen atoms by sharing of two electrons. (see fig 9.3).

The O_2 molecule is formed by chemical combination of two oxygen atoms; and N_2 molecule is formed by the chemical combination of two nitrogen atoms. On drawing the electron-dot structures of these two molecules, it becomes clear that the two oxygen atoms in O_2 molecule are joined with each other by two covalent bonds, that is, a double bond, while the two nitrogen atoms in the N_2 molecule are joined with each other by three covalent bonds, that is, a triple bond (See figure 9.4)



9.4 Double Bond and Triple Bond

Use your brain power !

1. Atomic number of chlorine is 17. What is the number of electron in the valence shell of chlorine?
2. Molecular formula of chlorine is Cl_2. Draw electron-dot and line structure of a chlorine molecule.
3. The molecular formula of water is H_2O. Draw electron-dot and line structures for this triatomic molecule. (Use dots for electron of oxygen atom and crosses for electrons of hydrogen atoms.)
4. The molecular formula of ammonia is NH_3. Draw electron-dot and line structures for ammonia molecule.

Now let us consider a carbon compound methane (CH_4). You have learnt about the occurrence, properties and uses of methane molecule in the previous standard. Just now we saw that carbon atom forms four covalent bonds using the four valence electrons and attain the configuration of the nearby noble gas neon (Ne) and obtains stability: Fig 9.5 shows the line structure and also the electron-dot structure of methane.

Do you know ?

To understand the structures of carbon compounds various types of molecular models are used. The fig 9.6 shows ball and stick model and space filling model of methane molecule.

Use your brain power !

1. The molecular formula of carbon dioxide is CO_2. Draw the electron-dot structure (without showing circle) and line structure for CO_2.
2. With which bond C atom in CO_2 is bonded to each of the O atoms?
3. The molecular formula of sulphur is S_8 in which eight sulphur atoms are bonded to each other to form one ring. Draw an electron-dot structure for S_8 without showing the circles.

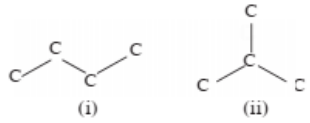
ELITE Tutors

Science I
Class 10
Page No. 116

Straight chain of carbon atoms	Structural formula	Molecular formula	Name
C		CH_4	Methane
C-C			Ethane
C-C-C			Propane
C-C-C-C			Butane
C-C-C-C-C			Pentane
C-C-C-C-C-C			Hexane
C-C-C-C-C-C-C			Heptane
C-C-C-C-C-C-C-C			Octane
C-C-C-C-C-C-C-C-C			Nonane
C-C-C-C-C-C-C-C-C-C			Decane

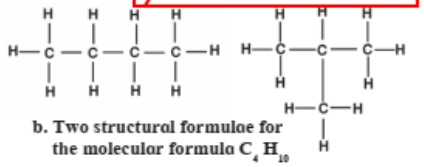
9.12 Straight chain hydrocarbon

Now let us pay more attention to the carbon chain in butane. The four carbon atoms can be joined to form a carbon chain in yet another way. (See fig 9.13 a)



(i) (ii)

a. Two possible carbon chains



b. Two structural formulae for the molecular formula C_4H_{10}

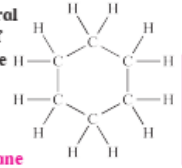
9.13 Two isomeric compounds with molecular formula C_4H_{10}

Two different structural formulae are obtained on joining hydrogen atoms to these two chains so as to satisfy the tetravalency of the carbon atoms. The molecular formula of both these structural formulae is the same which is C_4H_{10}. These are two different compounds as their structural formulae are different. The phenomenon in which compounds having different structural formulae have the same molecular formula is called 'structural isomerism'. The number of carbon compounds increases futher due to the isomerism obeserved in carbon compounds. The carbon chain (i) in the figure 9.13 (a) is a straight chain of carbon atoms, whereas the carbon chain (ii) is a branched chain of carbon atoms.

Apart from the straight chains and branched chains, closed chains of carbon atoms are present in some carbon compounds. Where in rings of carbon atoms form. For example, the molecular formula of cyclohexane is C_6H_{12} and its structural formula contains a ring of six carbon atoms. (See fig 9.14)

a. the carbon ring in cyclohexane

b. Structural formula of cyclohexene



9.14 Ring Structure of Cyclohexane

Do you know ?

In the course of millions of years the reserves of crude oil were formed from the dead organisms buried under the sea floor. This crude oil and natural gas are now recovered from the oil wells. The natural gas is mainly methane. The crude oil is a complex mixture of thousands of different compounds. It mainly contains various hydrocarbons. Various useful componenets such as CNG, LPG, petrol (gasoline), rocket, diesel, engine oil, lubricant, etc. are obtained by separation crude oil using fractional distillation.

Use your brain power !

Draw electron-dot structure of cyclohexane.

ELITE Tutors

Science I
Class 10
Page No. 127

Important carbon compounds : Ethanol and Ethanoic Acid

Ethanol and ethanoic acid are two of the commercially important carbon compounds. Let us now learn more about them.

At room temperature colourless ethanol is a liquid and its boiling points is 78 °C. Generally ethanol is called alcohol or spirit. Ethanol is soluble in water in all proportions. When aqueous solution of ethanol is tested with litmus paper it is found to be neutral. Consumption of small quantities of dilute ethanol shows its effect, even though is condemned still it has remained socially widespread practice. Consumption of alcohol harms health in a number of ways. It adversely affects the physiological processes and the central nervous system. Consumption of even a small quantitiy of pure ethanol (called absolute alcohol) can be lethal. Ethanol being good solvent, it is used in medicines such as tincture iodine (solution of iodine and ethanol), cough mixture and also in many tonics.

Do you know ?

Metanol (CH_3OH), the lower homologue of ethanol, is poisonous, and intake of its small quantity can affect vision and at times can be lethal. To prevent the misuse of the important commercial solvent ethanol, it is mixed with the poisonous methanol. Such ethanol is called denatured spirit. A blue dye is also added to it, so that it is easily recognised.

Chemical properties of ethanol

You have learnt about the oxidation reaction of ethanol in a previous unit of this chapter. Two more reactions of ethanol are as follows. The functional group -OH plays an important role in the reactions of ethanol.

(i) Reaction with sodium

$$2Na + 2\ CH_3\text{-}CH_2\text{-}OH \longrightarrow 2\ CH_3\text{-}CH_2\text{-}ONa + H_2$$

(Sodium ethoxide)

All the alcohols react with sodium metal to liberate hydrogen gas and form sodium alkoxide salts. In the reaction of ethanol with sodium metal, hydrogen gas and sodium ethaoxide are formed as products.

Try this. **Note : This activity should be demonstrated by the teacher.**

Apparatus : Big test tube, delivery tube fitted in a rubber cork, knife, candle, etc.

Chemicals : Sodium metal, ethanol, magnesium ribbon, etc.

Procedure : Take 10 ml ethanol in a big test tube. Cut sodium metal into 2-3 pieces of a serial grain size. Put the sodium pieces into the ethanol in the test tube and fix the gas delivery tube to the test tube. Take a burning candle near the out let of the gas delivery tube and observe.

1. Which is the combustible gas coming out of the gas delivery tube?
2. Why do the sodium pieces appear to dance on the surface of ethanol?
3. Repeat the above procedure using magnesium ribbon instead of sodium.
4. Do you see gas bubble released from the piece of magnesium ribbon?
5. Does magnesium metal react with ethanol?

Science I
Class 10
Page No. 128

In previous standard you have learnt that a moderately reactive metal such as magnesium reacts with strong acid to liberate hydrogen gas. Though ethanol is neutral, it reacts with sodium metal and liberates hydrogen gas. Sodium being highly reactive metal, it reacts with the neutral functional group-OH of ethanol.

(ii) Dehydration reaction : When ethanol is heated at the temperature 170 °C with excess amount of concentrated sulphuric acid, one molecule of water is removed from its molecule to form ethene, an unsaturated compound.

$CH_3\text{-}CH_2\text{-}OH \xrightarrow[\text{conc. } H_2SO_4]{170^\circ C} CH_2{=}CH_2 + H_2O$ Here, concentrated sulphuric acid acts as a dehydrating agent.

Use your brain power !

1. Explain by writing a reaction, what will happen when pieces of sodium metal are put in n- propyl alcohol.
2. Explain by writing a reaction, which product will be formed on heating n - butyl alcohol with concentrated sulphuric acid.

Science : Alcohol : A fuel

The sugarcane plant transforms solar energy into chemical energy very efficiently. When molasses, obtained during production of sugar from sugarcane, is subjected to fermentation, alcohol (ethanol) is obtained. On combustion in sufficient air ethanol gives carbon dioxide and water as the only products. In this way, ethanol is a clean fuel. Therefore in some countries it is used as an additive to increase the efficiency of petrol. Such a fuel is called gasohol.

Ethanoic acid: Ethanoic acid is a colourless liquid with boiling point118°C. Ethanoic acid is commonly known as acetic acid. Its aqueous solution is acidic and turns blue litmus red. Vineger, which is used as preservative in pickles, is a 5-8 % aqueous solution of acetic acid. The melting point of pure ethanoic acid is 17°C . Therefore during winter in cold countries ethanoic acid freezes at room temperature itself and looks like ice. Therefore it is named 'glacial acetic acid'.

Try this.

Apparatus: Glazed tile, glass rods, pH paper, blue litmus paper.
Chemicals : Dilute ethanoic acid, dilute hydrochloric acid

Procedure: Place two strips of blue litmus paper on a glazed tile. Put one drop of dilute hydrochloric acid on one strip with the help of a glass rod. Put one drop dilute ethanoic acid with the help of another glass rod on the other strip. Note the colour change taken place in the litmus strip. Repeat the same procedure using strips of pH paper. Note all the observation in the following table.

Substance	Colour change in blue litmus paper	Corresponding pH (Scratch the unwanted)	Colour change seen on the pH paper	Corresponding pH
Ethanoic acid		< 7 / 7 / > 7		
Hydrochloric acid		< 7 / 7 / > 7		

9.23 Testing ethanoic acid & Hydrochloric acid

Science I
Class 10
Page No. 131

Esters have sweet odour. Majority of fruits owe their odour to a particular ester present in them. Esters are used for making fragrances and flavouring agents. When an ester is reacted with the alkali sodium hydroxide, the corresponding alcohol and carboxylic acid (in the form of its sodium salt) are obtained back. This reaction is called saponification reaction, as it is used for preparation of soap from fats.

Ester + Sodium hydroxide ⟶ Sodium Carboxylate + Alcohol

Use your brain power !

When fat is heated with sodium hydroxide solution, soap and glycerin are formed. Which functional groups might be present in fat and glycerin? What do you think?

Macro molecules and Polymers

Can you tell?

1. What are the chemical names of the nutrients that we get from the food stuff, namely, serials, pulses and meat?
2. What are the chemical substances that make cloth, furniture and elastic objects?

Macromolecules : We have seen in the begining of this chapter that the number of the known carbon compounds is as large as about 10 million, and the range of their molecular masses is as large as 10^{1}- 10^{12}. The number of constituent atoms is very large for the molecules with high molecular mass. The giant carbon molecules formed from hundreds of thousands of atoms are called macromolecules. They are from the type of compounds called polymers.

Natural macromolecules : The natural macromolecules namely, polysaccarides, proteins and nucleic acids are the supporting pillars of the living world. We get food, clothing and shelter from polysaccarides, namely, starch and cellulose. Proteins constitute a large part of the bodies of animals and also are responsible for their movement and various physiological processes. Nucleic acids control the heredity at molecular level. Rubber is another type of natural macromolecule.

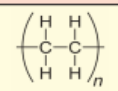
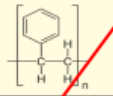
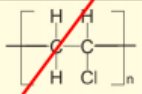
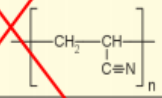
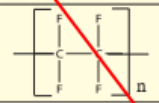
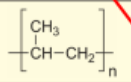
Manmade macromolecules : Macromolecules were produced for the first time in the laboratory and factory with an intention to invent an alternative for rubber and silk. Today manmade macromolecules are in use in every walk of life. Manmade fibres which have strength along the length similar to natural fibres cotton, wool and silk; elastomers which have the elastic property of rubber; plastics from which innumerable types of articles, sheets, pipes and surface coatings are made are all examples of manmade macromolecules. The structure of natural and manmade macromolecules is formed by joining several small units in a regular manner. As a result the macromolecules are polymeric in nature.

Polymers : A macromolecule formed by regular repeatition of a small unit is called polymer. The small unit that repeats regularly to form a polymer is called monomer. The reaction by which monomer molecules are converted into a polymer is called polymerization.

One important method of polymerization is to make a polymer by joining alkene type monomers. For example, synthesis of polyethylene is as shown further (see 9.26). Also, the table 9.27 shows the polymers used in large scale.

Science I
Class 10
Page No. 132

9.24 Synthesis of polyethylene

Name of polymer	Constituent monomer	Structural formula of the polymer	Uses
Polyethylene	Ethylene $CH_2 = CH_2$		Carry bags, sports wear
Polystyrene	Styrene $C_6H_5 - CH = CH_2$		Thermocoal articles
Polyvinyl chloride (PVC)	Vinyl chloride $Cl - CH = CH_2$		P.V.C. pipes, door mats, tubes and bags in hospital kits.
Polyacrylo nitrile	Acrylo nitrile $CH_2 = CH - C \equiv N$		Winter clothing, blankets
Teflon	Tetrafluro ethylene $CF_2 = CF_2$		Nonstick cookware
Polypropylene	Polypropylene $CH_3 - CH = CH_2$		Injection syringe, Furniture

9.27 Various polymers and their uses

The polymers in the above examples are formed by repetition of single monomer. These are called homopolymers. The other type of polymers are formed from two or more monomers. They are called copolymers. For example, PET is poly ethylene terephthalate. The structures of polymers are linear as in the above examples or they are branched and cross linked as well. Polymers aquire various properties as per the nature of the monomers and the type of structure.

The composition and structure of natural polymers were understood after carrying out their decomposition. The composition of the main natural polymers in given in the Table 9.28.

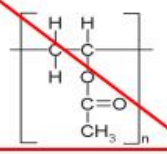
ELITE Tutors

Science I
Class 10
Page No. 133

Polymer	Name of the monomer	Occurrence
Polysaccaride	Glucose	Starch
Cellulose	Glucose	Wood (cell walls of plant cells)
Proteins	alpha amino acids	Muscles, hair, enzymes, skin, egg
D.N.A.	Nucleotide (base-deoxyribose-phosphate)	Chromosomes of animals
R.N.A.	Nucleotide (base-ribose-phosphate)	Chromosomes of plants
Rubber	Isoprene $CH_2=C(CH_3)-CH=CH_2$	Latex of rubber tree

9.28 Some natural polymers and their occurence

2. From the given structural formula of polyvinyl acetate, that is used in paints and glues, deduce the name and structural formula of the corresponding monomer.



Use your brain power !

1. Structural formulae of some monomers are given below. Write the structural formula of the homopolymer formed from them.

a. $CH_2=C(CH_3)-CH_3$

b. $CH_2=C(CH_3)-CN$

Exercise

1. **Match the pairs.**

Group 'A'	Group 'B'
a. C_2H_6	1. Unsaturated hydrocarbon
b. C_2H_2	2. Molecular formula of an alcohol
c. CH_4O	3. Saturated hydrocarbon
d. C_3H_6	4. Triple bond

2. **Draw an electron dot structure of the following molecules. (Without showing the circles)**

a. Methane b. Ethene

c. Methanol d. Water

3. **Draw all possible structural formulae of compounds from their molecular formula given below.**

a. C_3H_8 b. C_4H_{10} c. C_3H_4

4. **Explain the following terms with example.**

a. Structural isomerism
b. Covalent bond
c. Hetero atom in a carbon compound
d. Functional group
e. Alkane
f. Unsaturated hydrocarbon
g. Homopolumer
h. Monomer
i. Reduction
j. Oxydant

ELITE Tutors

Science I
Class 10
Page No. 135

10. Space Missions

- Space Missions
- Classification of artificial satellites
- Satellite launch vehicles
- Artificial satellites
- Orbits of artificial satellites
- Space missions away from the Earth

Can you recall

1. What is the difference between space and sky?
2. What are different objects in the Solar system?
3. What is meant by a satellite?
4. How many natural satellites does the earth have?

Man has always been curious about unknown places and he has always been eager to expand the horizons of his knowledge by exploring the unknown world. He must have had deep curiosity about the space and the many twinkling stars in the dark sky. He must have had dreams to fly to the space and must have been working for that.

Space missions

Substantial developments in technology, specially space technology, in the later half of twentieth century resulted in the development of space crafts making space voyage possible. Since then, more than a thousand artificial satellites have been placed into orbits around the earth. Additionally, space missions have been undertaken for close observation of various objects in our solar system. We will learn about all this in this chapter.

We can classify the space missions into two categories. In one type of missions, the objective is to put artificial satellites in orbits around the earth for research and various other useful applications. The objective of second type of missions is to send the spacecrafts to outer space for close observations and understanding of the objects in solar system, or even outside the solar system.

Do you know ?

The first person to go into the space in a spacecraft was Yuri Gagarin of the then USSR. He orbited the earth in 1961. The first person to step on the Moon (1969) was Neil Armstrong of USA. Rakesh Sharma of India orbited the earth in 1984 in a Russian spacecraft. Kalpana Chawla and Sunita Williams of Indian origin also participated in space explorations through missions organized by NASA (National Aeronautics and Space Administration) of USA.

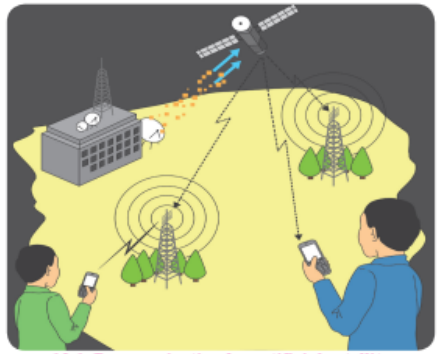
Can you recall?

Which types of telescopes are orbiting around the earth? Why it is necessary to put them in space?

Can you tell?

Where does the signal in your cell phone come from? Where from does it come to mobile towers? Where does the signal to your TV set come from? You may have seen photographs showing the position of monsoon clouds over the country, in the newspaper. How are these images obtained?

Science I
Class 10
Page No. 136



10.1 Communication by artificial satellite

Need and importance of space missions:

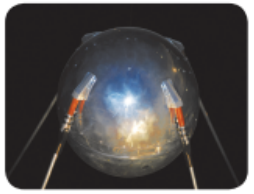
The world has become a global village due to space missions. Today, we can contact a person in any part of the world within a second. We can gather information about worldwide events sitting at home. You all know the importance of internet. Due to internet, every information is available at our fingertips. It has become possible to get advance alert about natural calamities and take proper precautions.

During war, it is possible to get information about the actions of the enemy through aerial surveillance using satellites. It is also possible to explore the fossil reserves and minerals in the earth. Thus, there are unlimited applications of space missions. Today, space technology is an inevitable part for development of a nation.

Artificial satellite

A natural satellite is an astronomical object orbiting the earth or any other planet. The moon is the only natural satellite of the earth. Some other planets in the solar system have more than one natural satellites. Similarly if a manmade object revolves around the earth or any other planet in a fixed orbit it is called an artificial satellite (fig 10.1).

The first artificial satellite *'Sputnik'* was sent to space by Soviet Union in 1957(see figure 10.2). Today, more than thousand satellites are orbiting the earth. The satellites work on solar energy. So, solar photovoltaic panels are attached on both sides of these satellites like wings. Instruments are installed in the satellites to receive and transmit signals from and to the earth.



10.2 *Sputnik*

The satellites have various other types of instruments, depending on their functions. One such satellite is shown in figure 10.1. Signals transmitted from the earth to the satellite and from the satellite to a mobile tower and mobile phone are also shown. These satellites are sent into the space to perform various functions. Depending on their functions, satellites are classified into following categories:

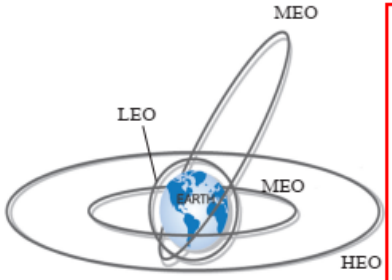
Use of ICT

Prepare a power point presentation showing India's contribution in space research and present it in the class.

INSAT: Indian National Satellite
GSAT: Geosynchronous Satellite
IRNSS: Indian Regional Navigation Satellite System
IRS : Indian Remote Sensing Satellite
GSLV: Geosynchronous Satellite Launch Vehicle
PSLV: Polar Satellite Launch Vehicle

ELITE Tutors

Science I
Class 10
Page No. 139



10.4 Orbits of satellites

Do you know ?

A group of students from COEP (College of Engineering, Pune) made a small satellite and sent it to the space through ISRO in 2016. The name of the satellite is 'Swayam' and it weighs around 1 kg. It is orbiting the earth at a height of 515 km. The main objective of the satellite was to provide point to point messaging services using a special method.

Solved Example

Example 1. Suppose the orbit of a satellite is exactly 35780 km above the earth's surface. Determine the tangential velocity of the satellite.

Given : $G = 6.67 \times 10^{-11}$ N m^2/kg^2 ,
$M = 6 \times 10^{24}$ kg (for earth)
$R = 6400$ km (for earth) $= 6.4 \times 10^6$ m ,
h = height of the satellite above the earth's surface 35780 km
$v = ?$
$R + h = 6400 + 35780 = 42180 \times 10^3$ m

$$v = \sqrt{\frac{GM}{R+h}}$$

$$= \sqrt{\frac{(6.67 \times 10^{-11}) \times (6 \times 10^{24})}{42180 \times 10^3 \text{ m}}}$$

$$= \sqrt{\frac{40.02 \times 10^{13}}{42180 \times 10^3}}$$

$$= \sqrt{\frac{40.02}{42180} \times 10^{10}}$$

$$= \sqrt{0.0009487909 \times 10^{10}}$$

$$= \sqrt{9487909}$$

$v = 3080.245$ m/s $= 3.08$ km/s

Example 2. In the previous example, how much time the satellite will take to complete one revolution around the earth?

Given: Height of the satellite above the earth's surface= 35780 km.

Velocity of the satellite=3.08 km/sec

Solution: Suppose the satellite takes T seconds to complete one revolution around the earth. The distance travelled during this one revolution is equal to the circumference of the circular orbit. If r is the radius of the orbit, the satellite will travel a distance $2\pi r$ during one revolution. Thus, the time required for one complete revolution can be obtained as follows:

$$v = \frac{\text{distance}}{\text{time}} = \frac{\text{circumference}}{\text{time}} = \frac{2\pi r}{T}$$

$$T = \frac{2\pi r}{v} = \frac{2\pi (R+h)}{v}$$

$$= \frac{2 \times 3.14 \times (6400 + 35780)}{3.08}$$

$= 86003.38$ sec

$= 23.89$ hrs. $= 23$ hrs 54 M.

(Here, since the velocity is taken in the unit of km/s, the radius is also taken in unit of km)

ELITE Tutors

Science I
Class 10
Page No. 141

Always Remember

The 'rocket', a type of fire-cracker used in Diwali, is also a sort of launcher. In this rocket, the fuel is ignited using a fuse and the rocket is projected into the sky just like a satellite launcher. Similarly, if a balloon is blown and released with its end open, the air in the balloon is forcefully ejected and the balloon is pushed in opposite direction. This can be explained using the Newton's third law of motion.

Space missions away from earth

As we have seen above, artificial satellites are being used for making our life more and more enriched. However, in the previous standard, we have learnt about how the telescopes aboard artificial satellites are used to gather information about various objects in the universe. Similarly some space missions are used to gain futher knowledge about the universe. In these missions, spacecrafts are sent to the nearby objects in the solar system to observe them more closely. New information has been obtained from such missions and it is helping us to understand the creation and evolution of our solar system.

For such missions, the spacecrafts must escape the earth's gravitational force to travel into the outer space. To achieve this, the initial velocity of the moving object must be greater than the escape velocity of the earth as we have learnt in the Chapter on Gravity. Escape velocity on a planet can be obtained using following formula:

$$V_{es} = \sqrt{\frac{2GM}{R}}$$

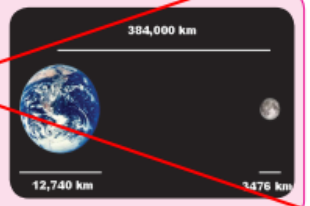
G = Gravitational constant = 6.67×10^{-11} N m^2/kg^2
M = mass of the planet = 6×10^{24} kg (for earth)
R = Radius of the planet = 6.4×10^6 m (for earth)

$$V_{es} = \sqrt{\frac{2 \times 6.67 \times 10^{-11} \times 6 \times 10^{24}}{6.4 \times 10^6}} = 11.18 \times 10^3 \text{ m/s} = 11.18 \text{ km/s}$$

Thus, if a spacecraft is to escape the earth's gravitational force to travel to the outer space, it must have minimum velocity of 11.2 km/s.

Do you know ?

The astronomical object closest to us is the moon. Light takes 1s to reach from moon to the earth. It means that if we travel with the speed of light, it will take 1s to reach the moon. However since a spacecraft travels at much smaller speed, it takes longer time to reach the moon. The shortest time taken by a spacecraft to reach the moon, so far, is 8 hours and 36 minutes.



ELITE Tutors

Science I
Class 10
Page No. 142

Moon missions

Since the moon is the closest astronomical object to us, the first space missions to objects in the solar system were the missions to the moon. Such missions have so far been executed by USA, Soviet Union, European countries, China, Japan and India. The space crafts in the Luna series sent by Soviet Union reached near the moon. Luna 2, launched in 1959 was first such craft. After that, till 1975, 15 space crafts made chemical analysis of the moon and also measured its gravity, density and radiations. Last four crafts even landed on the moon and brought the samples of stones on the moon for analysis in the laboratories. All these missions were unmanned.

America also executed moon missions from 1962 to 1972. The specialty of these missions was that some of these were manned missions. In July, 1969, Neil Armstrong became the first human to step on the moon. In 2008, Indian Space Research Organization (ISRO) successfully launched Chandrayaan- 1 and placed it an into an orbit around the moon. It sent useful information to earth for about a year. The most important discovery made during the mission was the presence of water on the moon surface. India was the first country to discover this.

Mars missions

Next to the moon, the astronomical object nearest to the earth is the Mars. Many nations sent space crafts to the Mars. Mars mission is difficult and almost half the missions were unsuccessful. However, ISRO's performance in this mission is remarkable and we all must be proud of it. The spacecraft '*Manpalyaan*' made by ISRO using mimimum expences was launched in November, 2013 and was placed into orbit around the Mars in September, 2014. It obtained very useful information about the surface of the Mars and the atmosphere around it.

Rakesh Sharma

Rakesh Sharma was the first Indian to travel to space. He went into space along with two Russian astronauts under the joint Indo - USSR space programme. He stayed in space for 8 days.

Kalpana Chawla

Kalpana Chawla obtained her Engineering in Aeronautics degree from Punjab and in 1988 obtained her doctorate from University of Colorado. She was in space for 336 hrs during research mission.While returning to earth from space, on 1st February, 2003, the Columbia space craft exploded and Kalpana perished.

Sunita Williams

Sunita Williams travelled to the international space station in space shuttle Discovery in 2006. She worked for 29 hrs outside the space station. She created a record by staying for 192 days in space.

Missions to other planets

Many missions have been executed to study other planets also. In some of these missions the space crafts orbited the planets, some landed on the planets and some just passed near the planet and observed them. Additionally, spacecrafts have been sent to observe asteroids and comets and they have successfully collected some dust and stones from the asteroids and brought them back on the earth. We are getting very useful information from all these missions clarifying our concepts about the origin and evolution of the solar system.

Science I
Class 10
Page No. 143

That's All

India and space technology

India also has made remarkable progress in the science and technology of launch vehicles. Various types of launch vehicles have been developed to put satellites having weight upto 2500 kg, into all types of orbits. PSLV and GSLV are two important launchers. The scientific and technological feats achieved by India in this field have a significant contribution to the national and social development. INSAT and GSAT satellite series is activly working in the field of telecommunication, television broadcasting and meteorological services. Availability of television, telephone and internet services all over the nation has been possible due to these satellites only. EDUSAT satellite in this series is used specially in the field of education. IRS satellite series is working for monitoring and management of natural resources and disaster management. To exactly locate position of any place on the earth's surface in terms of its precise latitude and longitude, the IRNSS satellite series has been established.

Read about:

Satellite Launch Centers:
1. Thumba, Thiruvanathapuram
2. Sriharikota
3. Chandipur, Odisha

Space Research Organizations:
1. Vikram Sarabhai Space Center, Thiruvanathapuram
2. Satish Dhavan Space Research Center, Sriharikota
3. Space Application Center, Ahmedabad

Introduction to scientists

Vikram Sarabhai is considered as the father of Indian space program. His efforts led to foundation of Physical Research Laboratory (PRL) at Ahmedabad. In 1962, Indian government constituted 'Indian National Committee for Space Research' under his Chairmanship and first satellite launch center was established at Thumba in 1963. The launching of India's first satellite 'Aryabhatta' into the space, was the result of his efforts. He played an important role in the establishment of Indian Space Research Organization (ISRO).

Space Debris and its management

In addition to the artificial satellite, some other objects are also revolving around the earth. It includes, non-functional satellites, parts of the launcher detached during launching and debris generated due to collision of satellite with other satellite or any other object in the space. According to one estimation made in 2016, there are about 2 crore pieces of length more than 1 cm, revolving around the earth! All this is nothing but the debris in space.

This debris can be harmful to the artificial satellites. It can collide with these satellites or space crafts and damage them. This debris is increasing day by day. Soon, it will be difficult to launch new spacecrafts. It is, therefore, very essential to manage the debris. Some studies and experiments are being done with this in view. Hope that soon we will have a solution for this problem and the future satellites and spacecrafts will not be in danger any more.

Books are my friends: For more information read the reference books in your library.

1. Space and science - Dr. J V Narlikar.
2. Story of ISRO - Dr. V. R. Gowarikar.