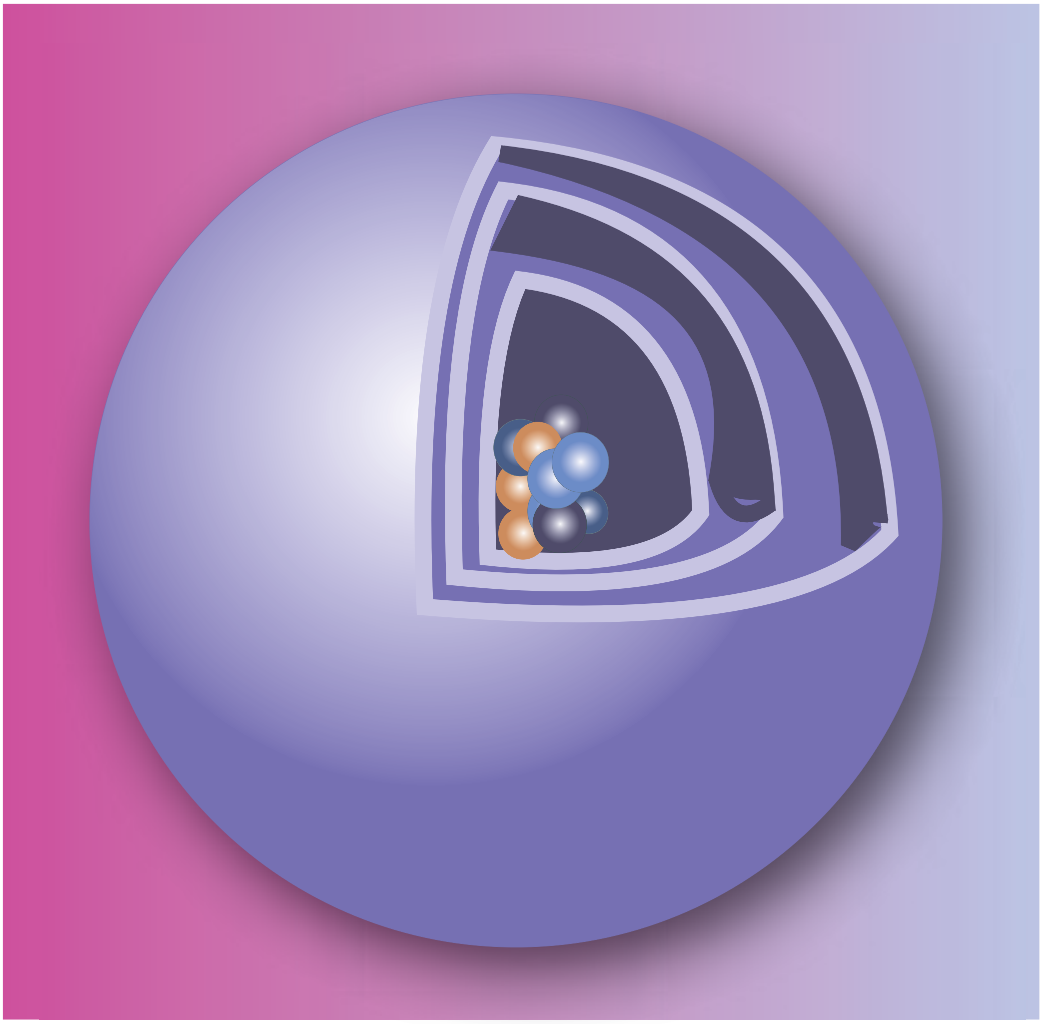
Chapter 10



ATOMIC STRUCTURE

Take a stone. Break it into several pieces. Powder all the pieces. Each particle of powder is composed of atoms. There is no particle without atoms. Once it was believed that atoms couldnot be divided. But today scientists have revealed that each atom consists of further smallest particles. The study of internal structure of atom proves the presence of such particles.

The development of modern atomic theories is an excellent example of how science progresses.Many scientists contribute their knowledge for development. New experiments lead to either changes in the old theories or even to new theories. Theories are useful in providing the basis for further work. Although, J.J.Thomson's atomic theory explained electrical neutrality of atoms, it could not reveal the presence of nucleus in an atom, which was later in 1909 proposed by Ernest Rutherford.

10.1. DISCOVERY OF THE NUCLEUS

Rutherford's contribution

Rutherford observed what happens to alpha particles projected at a thin metal foil.

Ernest Rutherford (1871-1937)

Ernest Rutherford, a british physicist probed atoms with alpha particles. He was known as the "father of nuclear physics". He was awarded Nobel Prize for his contribution in structure of atom in 1908.

MORE TO KNOW

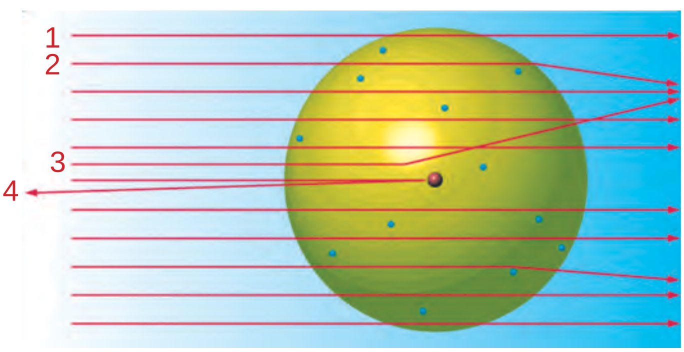
Alpha particles are helium ions He^{2+} .The mass of an alpha particle is about 8000 times the mass of an electron. Velocity of alpha particles is about $2x10^7$ m/s.

10.2. RUTHERFORD'S EXPERIMENT

A stream of alpha particles was made to pass through a thin gold foil of about $4x10^{-5}$ cm thickness. Most of the alpha particles did go through the foil in a straight line. Some alpha particles were deflected through an average angle of 90^o .Rarely the path of 1 in 20,000 alpha particles scored a direct hit on the nucleus and returned by an angle of 180^o.

From this experiment, he concluded that there is a heavy positive charge occupying small volume, at the centre of an atom.

Alpha particles

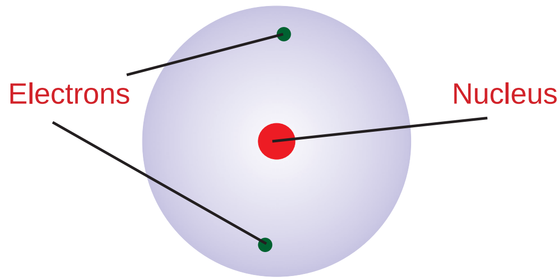


1. Not scattered at all 2. Slightly scattered 3. More scattered 4. Returned at 180^o

Schematic diagram showing alpha particles bombarding one gold atom. The nucleus of the gold atom is shown in the centre.

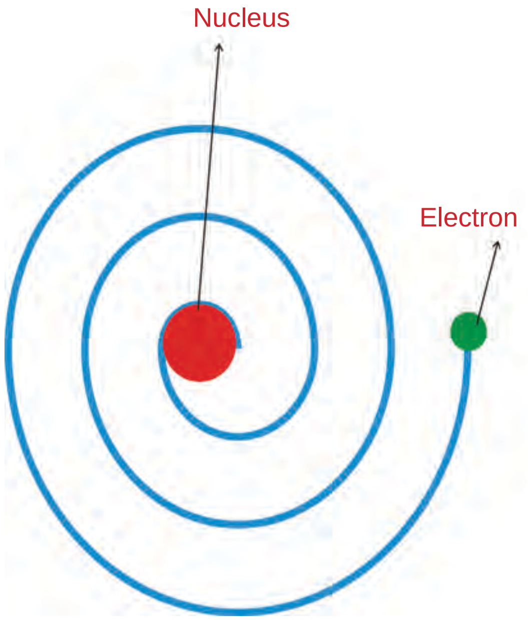
10.3. RUTHERFORD'S MODEL OF ATOM

Rutherford pictured the atom as consisting of a small, dense, positively charged nucleus containing most of the mass of the atom with the electrons in the space outside the nucleus .The moving electrons occupy most of the volume of the atom. The electrons must be moving very rapidly in the space around the nucleus.



10.3.1. LIMITATIONS

According to electromagnetic theory, a moving electron should accelerate and continuously lose energy. Due to the loss of energy, path of electron may reduce and finally the electron should fall into nucleus. If it happens so, atom becomes unstable. But atoms are stable. Hence Rutherford's theory does not explain the stability of atom.



ACTIVITY –10.1

In Rutherford's experiment,

1.Why did majority alpha particles pass through the foil unaffected?

2.Why were very few alpha particles deflected?

3.Is the size of nucleus small or large with respect to the size of atom?

MORE TO KNOW

Remember a small boy swinging a stone on the end of a string around him. The stone is able to occupy a larger volume because it is moving rapidly. Similarly the electrons in an atom are able to occupy a larger volume because they are moving very fast.

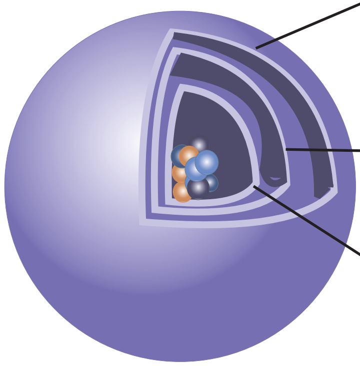
Neils Bohr (1885 - 1962)

Neils Bohr was born on October 7, 1885 in Copenhagen, Denmark. He was also an outstanding soccer player. He worked with Rutherford at the University of Manchestor. Bohr's theory became the basis for modern physics known as Quantum Mechanics.Bohr received the Nobel Prize for physics in 1922.

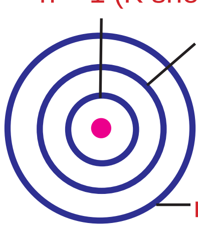
10.4. BOHR'S MODEL OF ATOM

Neils Bohr modified Rutherford's atom model and put forth the following postulates.

- In atoms, the electrons revolve around the nucleus in stationary circular paths. These paths are called orbits or shells or energy levels.
- As long as electrons revolve in the same orbit, it does not lose or gain energy.
- The circular orbits are numbered as 1, 2, 3, 4 or designated as K, L, M, N shells. These numbers are referred to as principal quantum numbers (n).
- Smaller the size of orbit, smaller is the energy of the orbit.
- As we move away from nucleus, energy of orbit is constantly increasing.
- Maximum number of electrons that can be accommodated in an energy level (n) is given by $2n^2$.



- When an electron absorbs energy, it jumps from lower energy level to higher energy level.
- When an electron returns from higher energy level to lower energy level, it gives off energy.



Orbit

Orbit is defined as the path, by which electrons revolve around the nucleus.

10.5. DISCOVERY OF NEUTRONS

In 1932, James Chadwick observed that when beryllium was exposed to alpha particles, particles with about the same mass as protons were given off. These emitted particles carried no electrical charge. Hence they were called as neutrons.

Beryllium + alpha ray ⟶ carbon + neutron

MORE TO KNOW

Number of neutrons = Mass number - Number of protons (Atomic number)

Characteristics of neutron

- Neutrons are particles with no charge.ie neutral particles.
- Neutrons are present in the nuclei of all atoms except hydrogen atom.
- Mass of a neutron is almost equal to the mass of a proton.
- Atoms of the same element with different number of neutrons are called as isotopes of the element.
- Neutron is also regarded as a sub-atomic particle.

10.6. CHARACTERISTICS OF FUNDAMENTAL PARTICLES

Physical and chemical properties of elements and their compounds can be explained by the fundamental particles of an atom. The fundamental particles of an atom are,

Protons: They are positively charged particles. They are present inside the nucleus.

Electrons: They are negatively charged particles. They revolve around the nucleus in circular orbits.

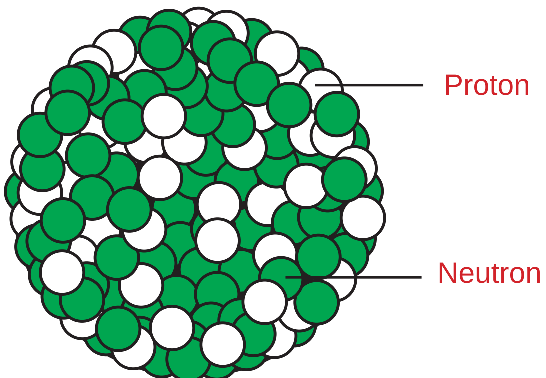
Neutrons: They are neutral particles. They are present inside the nucleus.

10.6.1. COMPOSITION OF NUCLEUS

Electrons have negligible mass. Hence the mass of an atom mainly depends on the mass of the nucleus. Nucleus of an atom consists of two components. They are protons and neutrons.

Protons are positively charged. Protons repel each other because of their like-charges. Hence, more than one proton cannot be packed in a small volume to form a stable nucleus unless neutrons are present.

Neutrons reduce the repulsive force between positively charged protons and contribute to the force that holds the particles in the nucleus together.



Nucleus

ACTIVITY –10.2

A has 11 protons, 11 electrons & 12 neutrons.

B has 15 protons, 15 electrons & 16 neutrons.

C has 4 protons, 4 electrons & 5 neutrons.

Identify the elements A, B and C?

10.7. ATOMIC NUMBER AND MASS NUMBER

Atomic number (Z)

We know that, an atom consists of positively charged protons and negatively charged electrons. Atom as a whole is electrically neutral. It is so, due to the presence of equal number of protons and electrons. This number is referred to as atomic number.

Atomic number of an atom can be defined as,

- The number of protons in the nucleus (OR)
- The number of electrons revolving around the nucleus.

ACTIVITY –10.3

Can you write the atomic numbers of (i) Beryllium (ii) Carbon (iii) Nitrogen (iv) Neon (v) Magnesium

Mass number (A)

We learnt that the mass of an atom entirely resides on the mass of nucleus. The mass of the lightest atom, hydrogen has been chosen as the unit of mass.Since the nucleus of an atom contains protons and neutrons, mass number (A) is defined as, the sum of the number of protons and neutrons in the nucleus of an atom

Mass Number (A) = Number of protons + Number of neutrons

MORE TO KNOW

In lighter atoms, one neutron per proton is enough. Heavier atoms with more protons in the nucleus need more neutrons in the nucleus, for the nucleus to be stable. Thus the stability of the nucleus is determined by the Neutron-Proton ratio.

ACTIVITY –10.4

Complete the following table

Species	Atomic number	number of protons	number of neutrons
Boron	5		
Sodium	11		
Phosphorus	15		
Neon	10		

Representation of Atomic number and Mass number

Superscript represents mass number.

Subscript represents atomic number.

For example,

Atomic number of nitrogen is 7.
Mass number of nitrogen is 14.

Representation: $_7N^{14}$

ACTIVITY –10.5

Which elements have the same number of neutrons?

1.Lithium-$_3Li^7$

2.Carbon- $_6C^{12}$

3. Nitrogen - $_7N^{14}$

4.Beryllium-$_4Be^8$

5.Oxygen- $_8O^{16}$

MORE TO KNOW

Chlorine has fractional atomic mass.

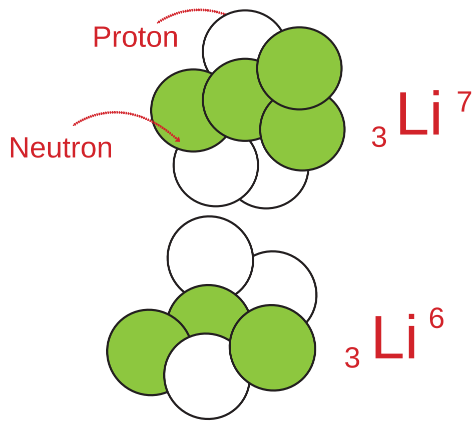
Chlorine-35 exists by 75%

Chlorine-37 exists by 25%

Average atomic mass of chlorine is,

$$\left\{\frac{75}{100}x35\right\}+\left\{\frac{25}{100}x37\right\} = 35.5$$

10.8. ISOTOPES



Isotopes of lithium

American scientist, T.W.Richards observed to his amazement that lead from samples collected in different places differed in atomic mass. This suggested that all atoms of an element are not exactly alike. It is clear that atoms of an element have the same chemical properties.But they may differ in their masses.

Isotopes are atoms of an element that differ in mass numbers, but having the same atomic number.

Characteristics of isotopes

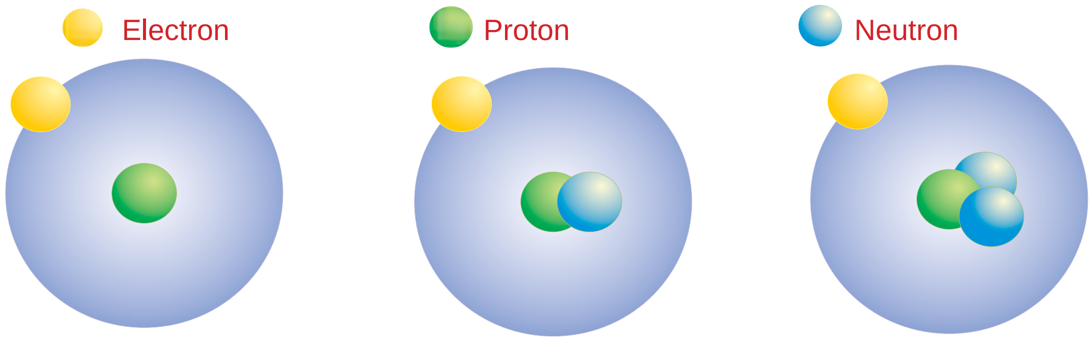
- Isotopes of an element differ in mass numbers only.
- Difference in mass number is due to difference in number of neutrons.
- Isotopes of an element have the same chemical properties.
- However, variation in physical properties are noted in isotopes.
- Elements having isotopes exhibit fractional atomic mass.

ACTIVITY –10.6

(i) Can you calculate the number of neutrons in the isotopes.

(a) $_1H^1$, $_1H^2$, $_1H^3$ (b)$_{17}Cl^{35}$, $_{17}Cl^{37}$

(ii) What do you infer from the result?



Hydrogen atom (Common hydrogen) | Deuterium atom (Heavy hydrogen) | Tritium atom (Radioactive hydrogen)

Isotopes of Hydrogen

Element	Isotope	Representation
Hydrogen	Protium Deuterium Tritium	$_1H^1$ $_1H^2$ (or) $_1D^2$ $_1H^3$ (or) $_1T^3$
Chlorine	Chlorine-35 Chlorine-37	$_{17}Cl^{35}$ $_{17}Cl^{37}$
Carbon	Carbon-12 Carbon-14	$_6C^{12}$ $_6C^{14}$
Uranium	Uranium-235 Uranium-238	$_{92}U^{235}$ $_{92}U^{238}$

ACTIVITY –10.7

The element bromine has the following isotopes.

Bromine-79 (49.7%) and Bromine-81 (50.3%)

Can you calculate the average atomic mass of Bromine?

Uses of Isotopes

- Many isotopes find use in medical field.
- Iron-59 isotope is used in the treatment of anaemia.
- Iodine-131 isotope is used for treatment of goitre.
- Cobalt-60 isotope is used in the treatment of cancer.
- Phosphorous-32 isotope is used in eye treatment.
- Carbon-11 isotope is used in brain scan.

ACTIVITY –10.8

From the given average atomic mass, which element does exist with least number of isotopes?

- Chlorine-35.5
- Hydrogen-1.008
- Oxygen-16.0

10.9. ELECTRONIC CONFIGURATION OF ATOMS

It is known that atoms consist of a positively charged nucleus with protons and neutrons in it. Negatively charged particles called electrons constantly revolve around the nucleus in set of orbits. The electron orbits are numbered as 1, 2, 3, etc, starting from the orbit closest to the nucleus. These orbits are also called **K, L, M, N** shells, as mentioned in the atom model proposed by Niel's Bohr.

The maximum number of electrons in an orbit is given by $\mathbf{2n^2}$, where **n** is the orbit number.

- For the first **orbit n = 1**, and the number of electrons it can hold is $\mathbf{2x1^2=2}$.
- For the second **orbit n = 2**, and it can hold a maximum of $\mathbf{2x2^2=8}$ electrons.
- For the third **orbit n = 3**, and it can hold a maximum of $\mathbf{2x3^2=18}$ electrons.

It must be understood that the second orbit begins only after the first orbit is filled.

The third orbit begins to fill only after the second orbit is filled. But the fourth orbit commences even before the third orbit is completely filled. The reason for this lies in the concept of quantum numbers.

Thus the term electronic configuration or electronic structure refers to the way, the electrons are arranged around the nucleus. Most of the properties of elements and their compounds depend on their electronic configurations.

To write electronic configuration, the principal quantum number of the shells must be known. This number describes the number of orbits present in the atom.

Let us consider sodium atom.

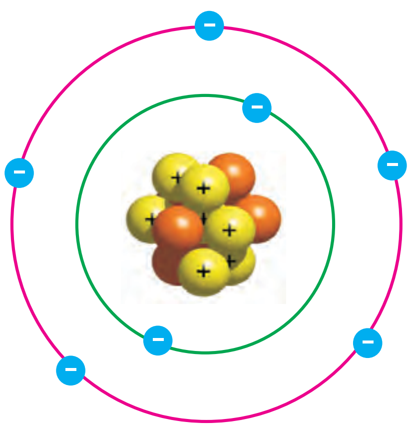
Atomic number of **sodium** = Total number of electrons in sodium = **11**

Orbit wise distribution of electrons

Orbit	Number of electrons
1. **(K-Shell)**	*$2n^2 = 2x1^2 = 2$ electrons*
2. **(L-Shell)**	*$2n^2 = 2x2^2 = 8$ electrons*
3. **(M-Shell)**	*Remaining=1 electron*

The electronic distribution in sodium is **2, 8, 1.**

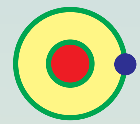
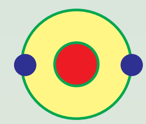
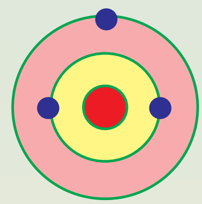
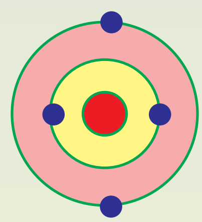
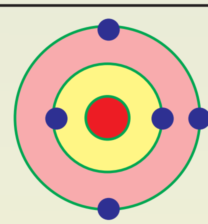
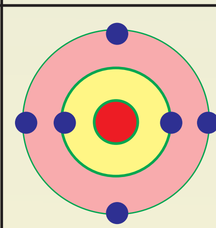
Electron distribution in nitrogen (2,5)



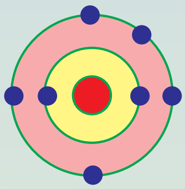
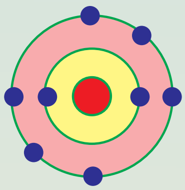
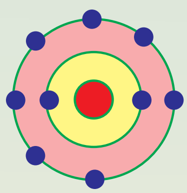
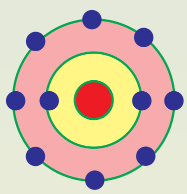
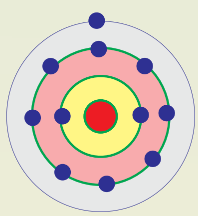
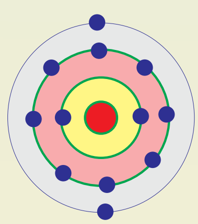
MORE TO KNOW

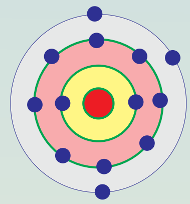
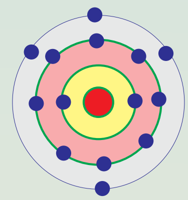
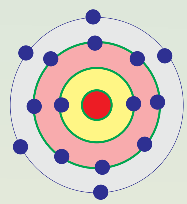
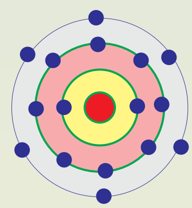
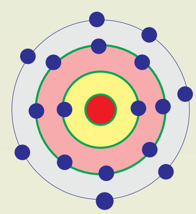
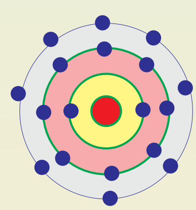
Much of the experimental evidence for electronic configuration comes from atomic spectra.

Some elements and their electronic configurations

Element	Atomic Number	Electron dot structure	Electron distribution
Hydrogen (H)	1		1
Helium (He)	2		2
Lithium (Li)	3		2,1
Beryllium (Be)	4		2,2
Boron (B)	5		2,3
Carbon (C)	6		2,4

Some elements and their electronic configurations

Element	Atomic Number	Electron dot structure	Electron distribution
Nitrogen (N)	7		2,5
Oxygen (O)	8		2,6
Fluorine (F)	9		2,7
Neon (Ne)	10		2,8
Sodium (Na)	11		2,8,1
Magnesium (Mg)	12		2,8,2

Element	Atomic Number	Electron dot structure	Electron distribution
Aluminium (Al)	13		2,8,3
Silicon (Si)	14		2,8,4
Phosphorus (P)	15		2,8,5
Sulphur (S)	16		2,8,6
Chlorine (Cl)	17		2,8,7
Argon (Ar)	18		2,8,8

ACTIVITY –10.9

Write the electron distribution

Element	Atomic number	Electron distribution		
		K	L	M
Lithium	3			
Boron	5			
Fluorine	9			
Magnesium	12			
Phosphorous	15			

10.9.1. VALENCE ELECTRONS AND VALENCY

The number of electrons in the outer energy level (orbit) of an atom are the ones that can take part in chemical bonding. These electrons are referred to as the valence electrons.

The outermost shell or orbit of an atom is known as valence shell or valence orbit. The electrons present in the outer shell are called valence electrons.

The number representing the valence electrons is used to calculate the valency of the element. This valency is regarded as the combining capacity of elements.

Illustration

Lithium (Atomic number:3) has the electronic distribution,

(n=1) K Shell 2 (electron)

(n=2) L Shell 1 (remaining electron)

Outer most shell is 'L'.

The valence electron = 1

The valency of Lithium = 1

When the number of electrons in the outermost shell is close to its full capacity, (such as 8 for L shell) valency is then determined by subtracting the valence electron number from the full capacity of 8.

For example fluorine (atomic number: 9) has the electron distribution,

n	shell	electrons
1	(K)	2
2	(L)	7

Outer shell (L) has 7 electrons which is close to the full capacity of 8.

Hence valency = (8 -7) = 1

ACTIVITY –10.10

Calculate the valence electrons and determine the valency.

Element	Atomic number	Valence electrons	Valency
Hydrogen	1		
Boron	5		
Carbon	6		
Magnesium	12		
Aluminium	13		

EVALUATION

SECTION - A

Choose the correct answer

1. Total number of electrons, that can be accommodated in an orbit is given by $2n^2$ (n = 1, 2, 3....). Maximum number of electrons, that can be present in first orbit is ________.
2. Goldstein discovered protons. It is present in the nucleus. Charge on the protons are ________ (negative, positive, neutral).
3. A subatomic particle is revolving around the nucleus in orbits. It is negatively charged. It was discovered by J.J.Thomson. Name the particle.
4. Number of neutrons present in $_3Li^7$ is 4. Find the number of neutrons present in $_8O^{16}$ element.
5. Nucleus of an atom has two components. They are proton and ________ (neutron, electron)
6. The sum of the number of protons and neutrons present in the nucleus is called mass number. Find the number of protons in the following element.

Element	Mass number	Number of protons	Number of neutrons
Sodium	23	?	12

7. Atomic number and mass number of $_{17}Cl^{35}$ are 17 and 35 respectively. What is the number of protons present in it?
8. ________ (Iodine – 131, Phosphorus – 32, Iron – 59) isotope is used for the treatment of goitre.
9. The electron distribution of fluorine is 2, 7. What is the valency of the element?
10. Electron distribution of sodium is 2, 8, 1. What is its valency?
11. Every atom has equal number of protons and electrons. Both are oppositively charged. Neutron is electrically neutral. What is the nature of atom?

SECTION - B

12. Electrons in an atom revolve around the nucleus in circular stationary paths?
    a) Who proposed such a statement?
    b) What is the name of the circular path?
13. K shell of $_7N^{14}$ has 2 electrons. How many electrons are present in the L shell?
14. $_{17}X^{35}$ is a gaseous element. Its atomic number is 17. Its mass number is 35. Find out the number of electrons, protons and neutrons.

15. Many Isotopes are used in medical field.
  a) Which isotope is used for the treatment of anaemia?
  b) Which one is used in eye treatment?

16. Write the electron distribution in the following elements.

Element	Atomic number	Electron distribution		
		K	L	M
Boron	5	2	-	-
Magnesium	12	-	8	-

17. Find the valence electrons and valency.

Element	**Atomic number**	**Valence electron**	**valency**
Carbon	6(2,4)		
Aluminium	13(2,8,3)		

18 . Atoms of the same element, having same atomic number and different mass numbers are known as Isotope. Mention the names of isotopes of hydrogen.

SECTION - C

19. Name the completely filled orbits.

Element	Atomic Number	Names of completely filled orbits
Nitrogen	7	
Neon	10	
Magnesium	12	
Sulphur	16	
Argon	18	

20. Correlate the facts with properties.

(i)	More dense part of an atom	valency
(ii)	Chargeless particle	Atomic number
(iii)	Outermost orbit	nucleus
(iv)	Number of electrons in outermost orbit	Valence shell
(v)	Number of protons	Neutron
		Proton

FURTHER REFERENCE

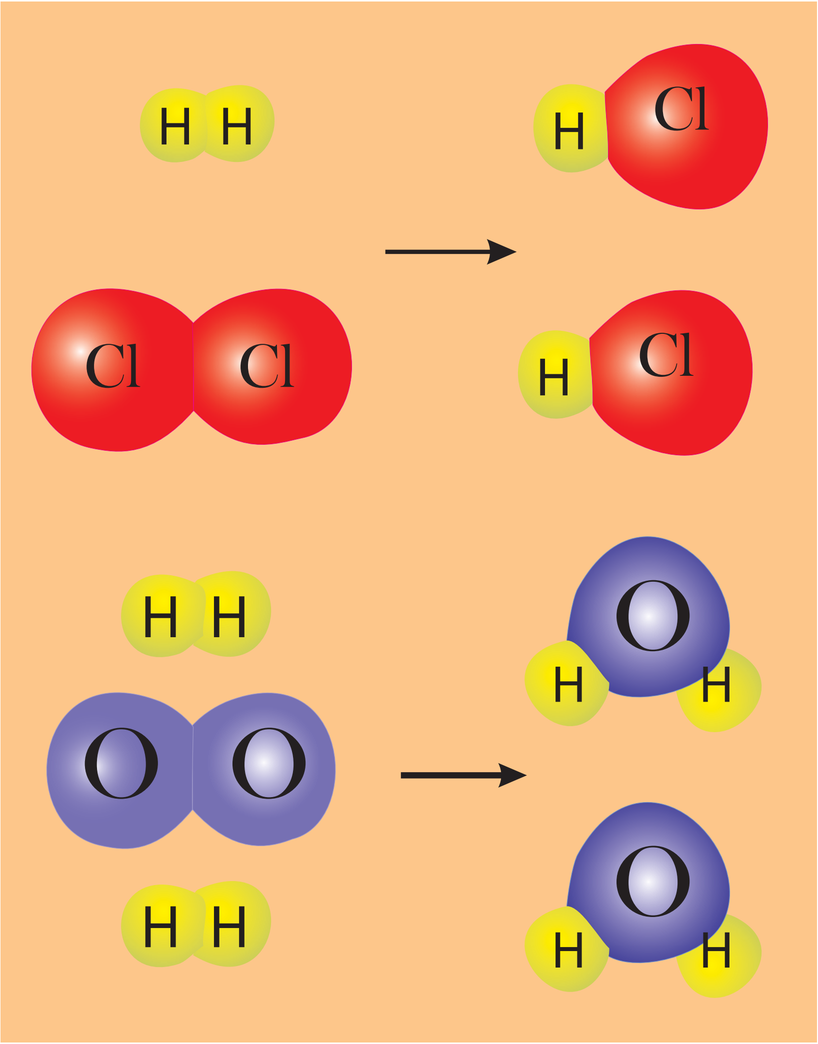
Book

Atomic Structure Advanced Inoganic Chemistry -
Satya prakash, GD Tuli - S.Chand & Company Ltd

Websites

http://www.shodor.org
http://www.chemguide.co.uk.

Chapter 11



CHEMICAL EQUATION

11. CHEMICAL EQUATION

Plants produce their food (carbohydrate) during photosynthesis. Essential requirements for photosynthesis are (i) sunlight, (ii) carbon dioxide, (iii) water, (iv) chlorophyll. The event of photosynthesis can be represented in a short way in the form of an equation,

$$\text{Carbon dioxide + Water} \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} \text{Carbohydrate + Oxygen}$$

Thus, chemical equations summarise information about chemical reactions. To write a chemical equation, you must identify the substances that are present before and after reaction.

11.1. TYPES OF IONS AND RADICALS

Ions are charged particles formed by the transfer of electrons from one atom of an element to another atom of an element. When atoms of reactive metals such as sodium combine with atoms of non-metals like fluorine to form compounds, enough electrons are transferred from one atom to another so as to attain the stable electronic distribution like noble (inert) gases with closest atomic number. Because the negative charge in the nucleus in an atom equals the positive charge in the nucleus, the loss of an electron leaves an ion with a positive charge.

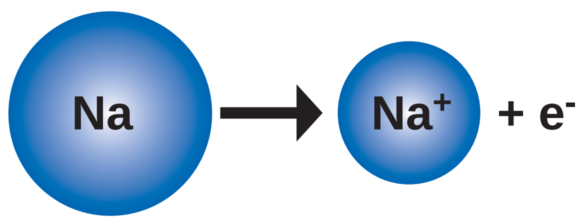
Formation of sodium ion from sodium atom

Atomic number of sodium is 11 and sodium atom has 11 electrons outside its nucleus. The inert gas closest to sodium is neon with atomic number 10. Hence, to get the same number of electrons as a neon atom, a sodium atom must lose one electron. Because atoms are electrically neutral, loss of one electron leaves a sodium ion with a +1 charge.

Sodium atom loses one electron

It is shown as

Na	$\longrightarrow$	Na^+ + e^-
(Sodium atom)		(Sodium ion)
11 protons &		11 protons &
11 electrons		10 electrons



Positively charged ions, such as Na^+ are called **cations**. **Metals usually form cations.**

Formation of fluoride ion from fluorine atom

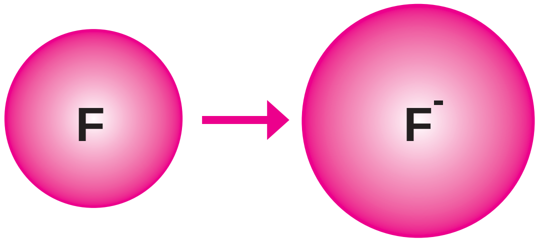
Non-metals usually gain electrons when they form ions. Fluorine is a non-metal. Atomic number of fluorine is 9. The inert gas that has an atomic number closest to 9 is neon, with atomic number 10. To get the same number of electrons as a neon atom, a fluorine atom must gain one electron. Since, atoms are electrically neutral, a gain of one electron gives a fluoride ion with a -1 charge.

Fluorine gains one electron

It is shown as

$F + e^- \longrightarrow F^-$

(Fluorine atom) 9 protons & 9 electrons → (Fluoride ion) 9 protons & 10 electrons



Negatively charged ions such as F^- are called anions. Nonmetals usually form anions.

Mono atomic ions

Mono atomic ions are formed from one atom.

Sodium ion (Na^+) is a mono atomic cation.

Fluoride ion (F^-) is a mono atomic anion.

Polyatomic ions

A poly atomic ion is a charged particle formed from more than one atom. These are group of atoms of different elements which behave as single units, and are known as polyatomic ions.

Consider the compound, sodium sulphate. It is made up of two parts, namely sodium and sulphate. The sodium found as a part of sodium sulphate compound is not sodium atom but it is sodium ion and sulphate is radical.

MORE TO KNOW

You cannot say how many cations and anions are found in a compound simply from the name.

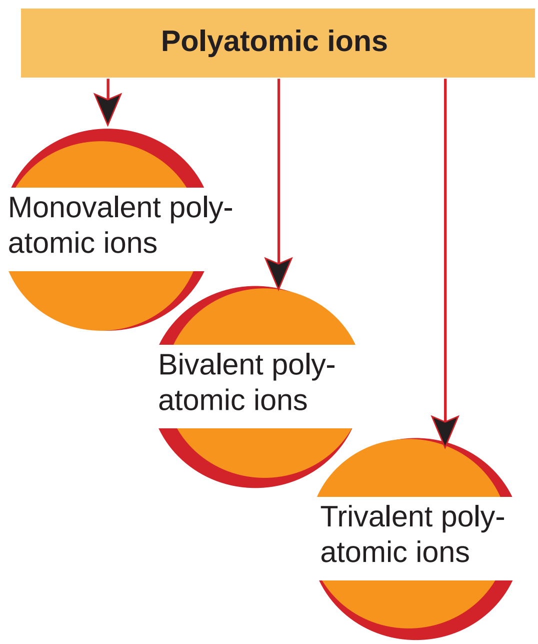
ACTIVITY –11.1

Write the formulas of the following mono atomic anions.

1.Bromide ion	5. Iodide ion
2.Chloride ion	6.Oxide ion
3.Fluoride ion	7. Nitride ion
4.Hydride ion	8.Sulphide ion

MORE TO KNOW

The names of most mono atomic negative ions end with suffix "ide".



Radical

A radical is defined as a positively or negatively charged monoatomic ion or polyatomic ion.

The compound sodium sulphate may be thought of as the product obtained when the base sodium hydroxide reacts with sulphuric acid.

Sodium hydroxide + Sulphuric acid ⟶ Sodium sulphate + water

In the compound sodium sulphate, sodium is called the basic radical, because it comes from the base sodium hydroxide and sulphate is called the acid radical because it comes from sulphuric acid.

MORE TO KNOW

Compounds that contain polyatomic ions are ionic in nature

Monovalent polyatomic ions

Name	Formula
Bisulphate ion	HSO_4^-
Bisulphite ion	HSO_3^-
Chlorate ion	ClO_3^-
Chlorite ion	ClO_2^-
Cyanide ion	CN^-
Hydroxide ion	OH^-
Hypochlorite ion	ClO^-
Nitrate ion	NO_3^-
Nitrite ion	NO_2^-
Perchlorate ion	ClO_4^-
Permanganate ion	MnO_4^-

Bivalent polyatomic ions

Name	Formula
Carbonate ion	CO_3^{2-}
Chromate ion	CrO_4^{2-}
Dichromate ion	$Cr_2O_7^{2-}$
Manganate ion	MnO_4^{2-}
Peroxide ion	O_2^{2-}
Sulphate ion	SO_4^{2-}
Sulphite ion	SO_3^{2-}
Thiosulphate ion	$S_2O_3^{2-}$

Trivalent polyatomic ions

Name	Formula
Borate ion	BO_3^{3-}
Phosphate ion	PO_4^{3-}

ACTIVITY –11.2

Identify and write cations and anions in the following compounds.

1. Silver nitrate
2. Magnesium sulphate
3. Aluminium oxide
4. Lead nitrate
5. Potassium carbonate
6. Barium chloride
7. Zinc sulphate
8. Copper nitrate

MORE TO KNOW

Ammonium ion is a polyatomic monovalent cation.It is represented by NH_4^+

ACTIVITY –11.3

Identify the polyatomic ions

1.Chloride ion
2.Chlorite ion
3.Oxide ion
4.Hydroxide ion
5.Phosphide ion
6.Phosphate ion

Multivalent cations or polyvalent cations

Formula	Name	Formula	Name
Au^{+}	Gold (I) or Aurous	Au^{3+}	Gold (III) or Auric
Ce^{3+}	Cerium (III) or Cerous	Ce^{4+}	Cerium (IV) or Ceric
Co^{2+}	Cobalt (II) or Cobaltous	Co^{3+}	Cobalt (III) or Cobaltic
Cr^{2+}	Chromium (II) or Chromous	Cr^{3+}	Chromium (III) or Chromic
Cu^{+}	Copper (I) or Cuprous	Cu^{2+}	Copper (II) or Cupric
Fe^{2+}	Iron (II) or Ferrous	Fe^{3+}	Iron (III) or Ferric
Mn^{2+}	Manganese (II) or Manganous	Mn^{3+}	Manganese (III) or Manganic
Pb^{2+}	Lead (II) or Plumbous	Pb^{4+}	Lead (IV) or Plumbic
Sn^{2+}	Tin (II) or Stannous	Sn^{4+}	Tin (IV) or Stannic

ACTIVITY –11.4

Write the names of following cations.

(i) Fe^{2+} (ii) Hg^{+}

(iii) Fe^{3+} (i) Hg^{2+}

MORE TO KNOW

A molecule formed by combination or association of two molecules is known as a dimer.

Hg_2^{2+} Mercurous ion exists as a dimer only.

Chemical symbols and valencies

Valency = 1	Valency = 2	Valency = 3	Valency = 4
Bromine (Br)	Barium (Ba)	Boron (B)	Carbon (C)
Chlorine (Cl)	Calcium (Ca)	Aluminium (Al)	Silicon (Si)
Fluorine (F)	Magnesium (Mg)		
Hydrogen (H)	Oxygen (O)		
Iodine (I)	Sulphur (S)		
Lithium (Li)			
Sodium (Na)			
Potassium (K)			

MORE TO KNOW

Most of the polyatomic names end with suffixes “-ite”,”-ate”.

11.2. LEARNING TO WRITE CHEMICAL SYMBOLS AND CHEMICAL FORMULAE BY CRISSCROSSING VALENCIES

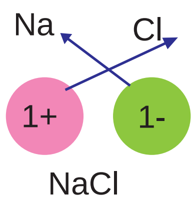
Chemical formula of the compound is the symbolic representation of its composition. To write chemical formula of a compound, symbols and valencies of constituent elements must be known. The valency of atom of an element can be thought of as hands or arms of that atom.

Writing a chemical formula

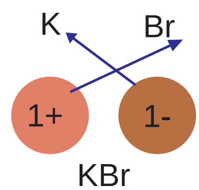
- The symbols or formulae of the component radicals of the compound are written side by side.
- Positive radicals are written left and negative radicals on the right.
- The valencies of the radicals are written below the respective symbols.
- The criss-cross method is applied to exchange the numerical value of valency of each radical. It is written as subscript of the other radical.
- The radical is enclosed in a bracket and the subscript is placed outside the lower right corner.
- The common factor is removed.
- If the subscript of the radical is one, it is omitted.

ILLUSTRATIONS

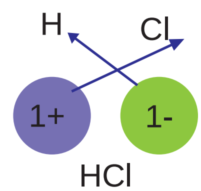
1. Sodium chloride



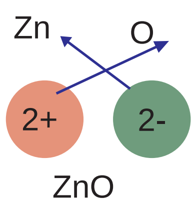
2. Potassium bromide



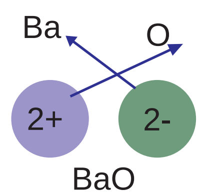
3. Hydrogen chloride



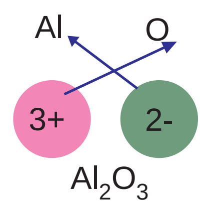
4. Zinc oxide



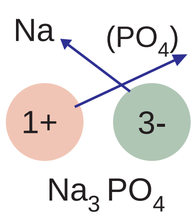
5. Barium oxide



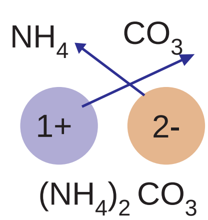
6. Aluminium oxide



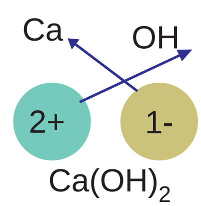
7. Sodium phosphate



8. Ammonium carbonate



9. Calcium hydroxide



Common Greek Prefixes

Prefix	Number
Mono -	1
Di -	2
Tri -	3
Tetra -	4
Penta -	5
Hexa -	6
Hepta -	7
Octa -	8
Nona -	9
Deca -	10

ACTIVITY –11.5

Write the chemical formula of the following compounds.

1. Sodium hydroxide
2. Sodium carbonate
3. Calcium hydroxide
4. Ammonium sulphate
5. Phosphorous trichloride
6. Sulphur hexafluoride
7. Copper (II) nitrate
8. Cobalt (II) chloride

MORE TO KNOW

Of over 13 million compounds known, 91% of them contain carbon.

1 million = Thousand thousands = (10 lakh)

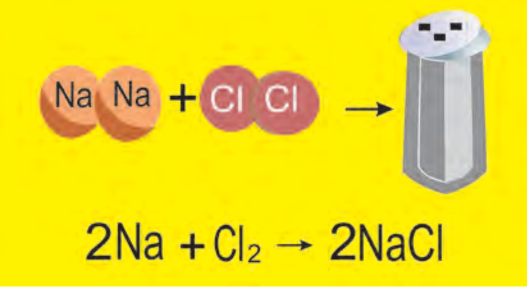
11.3. INTRODUCTION TO WRITE CHEMICAL REACTIONS

The first reaction known to be carried out by humans was combustion (burning). Combustion is the rapid reaction of materials with oxygen. Both heat and light are usually given off during combustion.

Fig: Combustion Reaction

The symbolic expression of a chemical reaction using symbols of reactants and products is called a chemical equation.

- Reactants are the substances that are present before a reaction takes place.
- Products are the substances that are formed in a reaction.
- The arrow sign means “react to form”.
- The plus sign means “and”.
- Any special conditions needed to make the reaction to take place are written above or below the arrow mark.



Thus, chemical equation is a short hand method of representing a chemical change.

The rules for naming inorganic compounds are summarized as,

Inorganic Compounds

Metal – Non-metal compounds

With one cation

Rule: Name of metal
+
Name of anion

Example:

Aluminium oxide (Al_2O_3)
Barium chloride ($BaCl_2$)
Calcium carbonate ($CaCO_3$)
Magnesium sulphate ($MgSO_4$)
Sodium nitrate ($NaNO_3$)

With more than one cation

Rule: Show cations with Roman numerals

Example:

Copper (I) oxide (Cu_2O)
Copper (II) oxide (CuO)
Iron (II) chloride ($FeCl_2$)
Iron (III) chloride ($FeCl_3$)
Tin (II) oxide (SnO)
Tin (IV) oxide (SnO_2)

Nonmetal – Non-metal compounds

Rule :

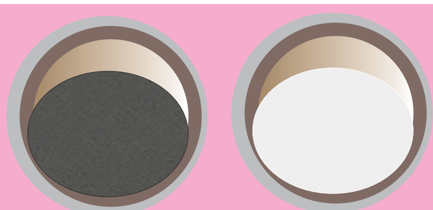
(i) Elements in left of the periodic table first.

(ii) If both elements are from the same group, lower one first.

(iii) Use Greek prefixes to show the number of atoms.

Example:

Carbon monoxide (CO)
Carbon dioxide (CO_2)
Sulphur dioxide (SO_2)
Sulphur trioxide (SO_3)



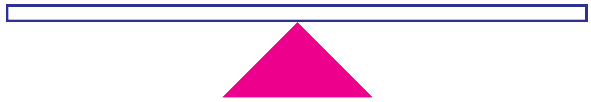
White – Tin (IV) oxide (SnO_2)
Black - Tin (II) oxide (SnO)

11.4. BALANCING THE CHEMICAL EQUATION

1. Identify reactants and products and write the equation in sentences.
2. Write symbols for elements and formulae for compounds.
3. Balance by changing coefficients in front of the symbols and formulae.
4. Do not change formulae or add or remove substances.
5. Check to be sure whether the same number of each kind of atom is shown on both sides.
6. If the coefficients have a common divisor, simplify.
7. If the product formed is a precipitate (solid separates from solution), use a downward arrow mark (↓).
8. If the product formed is gas, an upward arrow mark (↑) is used.

Balancing of chemical equations

$$2H_2 + O_2 \longrightarrow 2H_2O$$



It involves the following steps

1. Write the skeleton equation with correct formula of reactants and products.
2. Count the number of atoms of various elements on both the sides of the sign of equality and make them equal on both sides by multiplying the formulae by a suitable integer.
3. In case of diatomic gases appear as reactants or products; balance the equation by keeping the gases in atomic form.

Example 1: Reaction between Iron and Chlorine

Skeleton equation : $Fe + Cl_2 \longrightarrow FeCl_3$

Balance Cl atom : $Fe + 3Cl_2 \longrightarrow 2FeCl_3$

Balance Fe atom : $2Fe + 3Cl_2 \longrightarrow 2FeCl_3$

Example 2: Reaction of Sodium Carbonate with Hydrochloric acid

Skeleton equation : $Na_2CO_3 + HCl \longrightarrow NaCl + H_2O + CO_2$

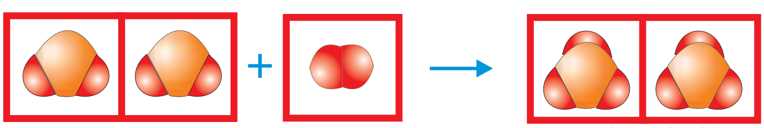
Balance sodium atom: $Na_2CO_3 + HCl \longrightarrow 2NaCl + H_2O + CO_2$

Balance hydrogen, chlorine and oxygen atoms:

$$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2$$

Balanced equations : Illustration 1

Reaction between sulphur-di-oxide and oxygen to form sulphur-tri-oxide:



Sulphur dioxide — Oxygen — Sulphur trioxide

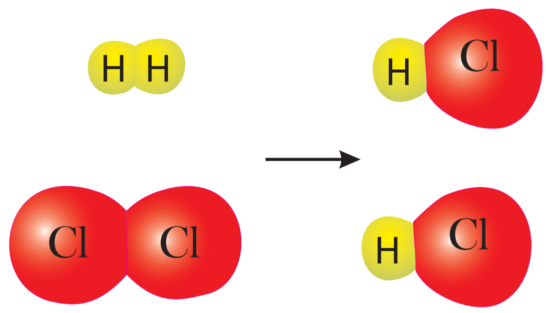
$$2SO_2 + O_2 \longrightarrow 2SO_3$$

ACTIVITY –11.6

Take 3ml of sodium hydroxide in a test tube. Add 5 ml of dilute hydrochloric acid. Name the salt formed. Write a balanced chemical equation

Illustration : 2

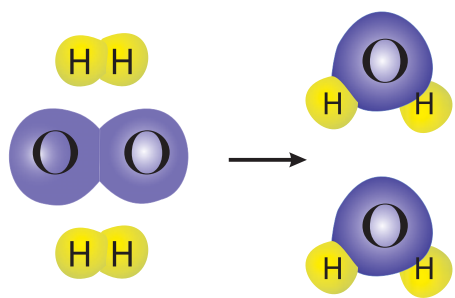
Reaction between hydrogen and Chlorine to form Hydrogen Chloride:



$$H_2 + Cl_2 \longrightarrow 2HCl$$

Illustration : 3

Reaction between hydrogen and oxygen to form water:

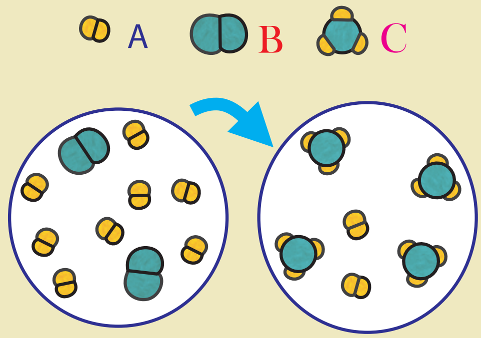


$$2H_2 + O_2 \longrightarrow 2H_2O$$

11.5. INFORMATIONS CONVEYED BY CHEMICAL EQUATIONS

- Reactants and products.
- Number of molecules.
- Number of moles.
- Relative masses.
- Relative volume.

ACTIVITY –11.7



From the diagram write the equation for the reaction between A and B to give the product C.

ACTIVITY –11.8

Balance the chemical equations.

1. $N_2 + O_2 \longrightarrow NO$
2. $CaCO_3 + HCl \longrightarrow CaCl_2 + H_2O + CO_2$
3. $Na + H_2O \longrightarrow NaOH + H_2$
4. $KClO_3 \longrightarrow KCl + O_2$
5. $N_2 + H_2 \longrightarrow NH_3$
6. $NH_3 + O_2 \longrightarrow N_2 + H_2O$

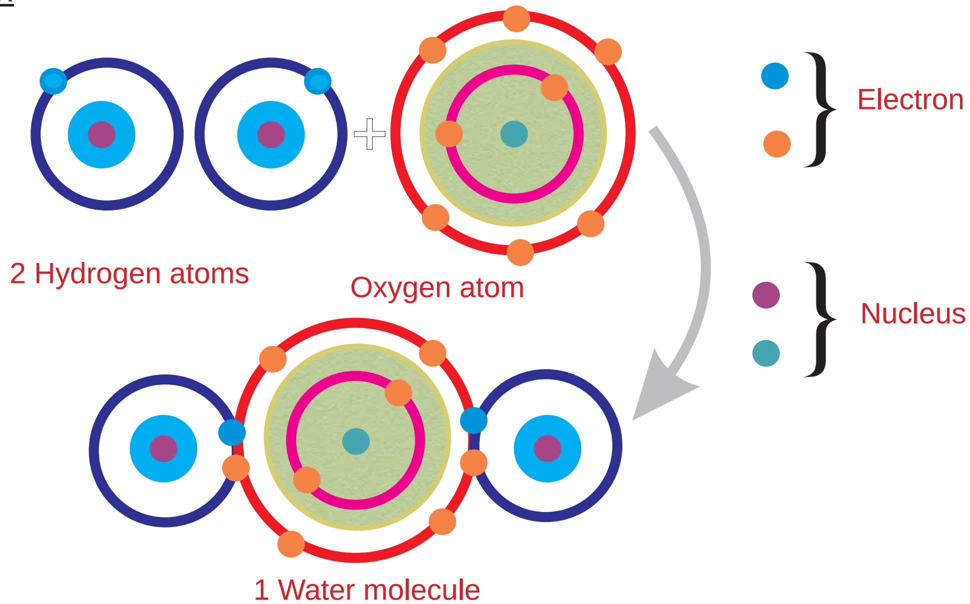
MORE TO KNOW

Most of the reactions take place in aqueous solutions. Example: All biological reactions,many geological processes, industrial reactions, including most of the reactions carried out in chemistry laboratory.

11.6. INFORMATIONS NOT CONVEYED BY CHEMICAL EQUATIONS.

- Nature of reactants and products.
- Heat changes.
- Reaction condition.
- Concentration.
- Time factor.
- Isotopes.

Illustration



$$2H_2 + O_2 \longrightarrow 2H_2O$$

The above balanced equation provides the following informations

(i) Reactants and products

In this reaction, hydrogen and oxygen are reactants and water is the product obtained.

(ii) Number of molecules

The equation shows that two hydrogen molecules and one oxygen molecule combine to form two molecules of water. The two molecules of water are made up of four hydrogen atoms and two oxygen atoms all together.

(iii) Number of moles

The relative number of moles of hydrogen, oxygen and water are in the ratio 2:1:2.

(iv) Relative masses

The relative masses of hydrogen, oxygen and water are in the ratio 4:32:36 which is equal to 1:8:9.

(v) Relative volumes

The relative volumes of hydrogen, oxygen and water are in the ratio 2:1:2.

The following informations are not conveyed by the chemical equation

(i) Nature of reactants and products

This equation does not convey any information about the physical states of hydrogen, oxygen and water.

(ii) Heat changes

A chemical reaction is always accompanied by heat changes. Such an information is not conveyed.

(iii) Reaction conditions

The favourable conditions of temperature and pressure to carry out the reaction are not mentioned.

(iv) Concentrations

The concentrations of hydrogen, oxygen and water are not furnished.

(v) Time factor

The time required for completion of the reaction is not specified.

(vi) Isotopes

There is no particular information about the isotopes of the elements hydrogen and oxygen.

Know the occurrence of natural chemical reaction

Some chemical reactions take place naturally during lightning. Nitrogen in the atmosphere combine with oxygen to form nitrogendioxide.

$$N_2 + 2O_2 \longrightarrow 2NO_2$$

Oxygen present in the atmosphere is converted to ozone.

$$3O_2 \longrightarrow 2O_3$$

This acidic oxide like nitrogendioxide mixes with tiny droplets of water vapour to produce acid rain which is harmful to plants.

$$4NO_2 + O_2 + 2H_2O \longrightarrow 4HNO_3$$

EVALUATION

Section A

Choose the correct answer

1. Sodium atom is electro positive in nature. Atomic number of sodium is 11. Then number of electrons in sodium ion is ________ (9,10,12)

2. If an atom undergoes loss of electron it becomes electro positive ion. Number of electrons lost by Fe^{2+} ion is ________ (2,3,0)

3. A chemical compound contains acid radical and basic radicals. The basic radical present in zinc sulphate compound is ________ (Zinc ion, Sulphate ion, both)

4. A polyatomic ion is a charged particle formed from more than one atom. Identify the polyatomic ion from the following

   Cl^- , O^{2-} , Na^+ , NH_4^+

5. An electronegative ion is formed by gaining of electrons. Select the mono atomic anions from the following

   CN^- , PO_4^{3-} , I^- , NO_2^-

6. An ion is produced as a result of gain or loss of electrons by an atom.

   In Au^{3+} ion, 3 electrons are ________. (gained, lost)

7. Reactants are the substances that are present before the chemical reaction takes place.

   $2Fe + 3Cl_2 \longrightarrow 2FeCl_3$. Name the reactants

8. A chemical formula is a symbolic representation of the constituents of a compound.

   Pick out the correct chemical formula of sodium carbonate.

   $Na_2(CO_3)_2$, $2NaCO_3$, Na_2CO_3

9. Valency of sodium is 1. Valency of chlorine is 1. Write the formula of sodium chloride.

10. The number of atoms of the reactants and products of various elements on both side are equal in a balanced chemical equation. Balance the following equation.

    $N_2 + H_2 \longrightarrow NH_3$

Section B

11. $Na \longrightarrow Na^+ + e^-$

    $Cl + e^- \longrightarrow Cl^-$

    a) Is sodium a metal or non-metal?

    b) Write the name of Cl^- ion.

12. A compound is formed by the combination of both acid and basic radicals. Mention the acid radical in the following compounds.

    a) K_2CO_3 b) $BaCl_2$

13. Match:

Cl^-	-	polyatomic anion
Cr^{2+}	-	monoatomic anion
NH_4^+	-	monoatomic cation
PO_4^{3-}	-	polyatomic cation

14. Name the anions present in the following compounds.

    a) NaCl b) KNO_3

15. Pickout the odd one

    a) NO_3^- , NO_2^- , MnO_4^- , Cl^-

    b) $BaCl_2$, $NaNO_3$, $MgSO_4$, Cu_2O

16. The given sentences are wrong. Correct the mistakes wherever necessary and write the correct sentences.

    a) Change the formulae wherever necessary.

    b) If the product formed is a precipitate, use upward arrow mark (↑).

17. Pick up the poly atomic anions from the following.

    Chloride ion, Fluoride ion

    Phosphate ion Sulphate ion

18. Atomic number of fluorine is 9. It becomes fluoride ion, after gaining an electron. Give the reason for its accepting nature of electron.

19. Valency of Zn is 2

    Valency of Oxygen is 2

    Construct the formula for zinc oxide by using the above hints.

20. Formula of Aluminium oxide is Al_2O_3. Find the valency of Aluminium and Oxygen.

Section – C

21. The formula of a compound formed between silicon and Oxygen is SiO_2. Predict the formula of the compound formed between

    (i) Carbon and Oxygen

    (ii) Silicon and Chlorine

    (iii) Carbon and Sulphur

    (iv) Calcium and Nitrogen

    (v) Aluminium and Fluorine

22. Identify the elements and compounds

    (i) Br_2 (ii) HF (iii) P_4 (iv) NH_3 (v) S_8

FURTHER REFERENCE

Book

General Chemistry - Jean B. Umland & Jon.M.Bellama
West publishing company

Websites

http://www.visionlearning.com
http://www.chymist.com

Chapter 12

PERIODIC CLASSIFICATION OF ELEMENTS

12. PERIODIC CLASSIFICATION OF ELEMENTS

In a fruit shop, there are different types of fruits. Are they kept in a heap?

They are arranged in a proper way. The stacking of fruits in the fruit stall involves

(i) types of fruits, (ii) their size, (iii) colour.

This type of arrangement is called classification. Similarly, in chemistry hundreds of elements have been discovered. It is necessary to classify them on the basis of some properties, which makes us useful to refer an element easily.

History of Periodic Table

More than one hundred elements, are known today. Inorder to track so many elements in a logical and semantic way, scientists studied many properties of elements. There are groups of elements having similar physical and chemical properties. For example, sodium vigorously reacts with water. Similarly, potassium also vigorously reacts with water. In addition, sodium and potassium are silvery white metals and are very soft. A similar prediction can be made about rubidium and cesium. Attempts have been made from time to time to classify the elements on the basis of their physical and chemical properties. This resulted in the concept called 'periodicity'.

12.1 EARLY ATTEMPTS OF CLASSIFICATION OF ELEMENTS

Lavoisier's classification of elements

In 1789, Lavoisier first attempted to classify the elements into two divisions namely Metals and Non-metals. However this classification was not satisfactory as there were many exceptions in each category.

Dobereiner's classification of elements

In 1817, Johann Wolfgang Dobereiner grouped three elements into what he termed triads.

In each case, the middle element has an atomic mass almost equal to the average atomic masses of the other two elements in the triad.

Chemically alike elements could be arranged in a group of three in which the atomic mass of the middle element was approximately the arithmetic mean of the two extreme elements.

For example, elements like lithium, sodium and potassium have atomic masses 7, 23 and 39 respectively. They are grouped together into a triad as,

Li (7)	Na (23)	K (39)

Note that the atomic mass of sodium is the average of atomic masses of lithium and potassium.

Limitation of Dobereiner's law

Only a limited number of elements could give such triads and this law failed to accommodate other elements resembling a lot with triads.

ACTIVITY –12.1

Element	Atomic Mass
Calcium	40
Strontium	88
Barium	137
Chlorine	35.5
Bromine	80.0
Iodine	127.0

Arrange the above elements in two groups of triads.

Newland's classification of elements

In 1863, John Newland suggested another classification of elements. He arranged the elements in the order of their increasing atomic masses. He noted that there appeared to be a repetition of similar properties in every eighth element. Therefore he placed seven elements in each group. Then he arranged the 49 elements known at that time into seven groups of seven each. Newland referred to his arrangement as the Law of octaves.

If elements be arranged in ascending order of their atomic masses then every eighth element was a kind of repetition of the first one either succeeding or preceding it like eighth note in octave of music.

For example,

Note	1 (Sa)	2 (re)	3 (ga)	4 (ma)	5 (pa)	6 (dha)	7 (ni)
Element	Li	Be	B	C	N	O	F
	Na	Mg	Al	Si	P	S	Cl
	K	Ca	Cr	Ti	Mn	Fe	-

Note: Sodium is similar to Lithium.

Similarly Magnesium is similar to Beryllium.

ACTIVITY –12.2

Write the name of element with similar properties	
Element	**Element with similar property**
Aluminium	
Silicon	
Phosphorous	
Sulphur	
Chlorine	

Periodicity is the recurrence of similar physical and chemical properties of elements when arranged in a particular order.

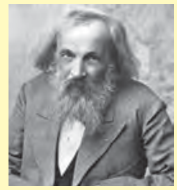
Limitations of Newland's classification

At that time inert gases were not discovered. Later, with the inclusion of inert gas, 'Neon' between 'Fluorine' and 'Sodium', it was the 9th element which became similar to the first. Similarly inclusion of inert gas 'Argon' between 'Chlorine' and 'Potassium' also made the 9th element similar to the first.

Lothar Meyer's classification of elements

In 1864, Lothar Meyer plotted atomic weight against atomic volume of various elements. He found that elements with similar properties and valency fell under one another. However, this also could not give the better understanding.

Mendeleev, a Russian chemist who was the first to propose that the seemingly different chemical elements can be sorted out according to certain similarities in their properties. The arrangement he proposed is called the periodic table. His table proved to be a unifying principle in chemistry and led to the discovery of many new chemical elements.



Mendeleev (1834-1907)

12.2 MENDELEEV'S PERIODIC TABLE

Groups	I	II	III	IV	V	VI	VII	VIII		
Oxide : Hydride:	R_2O RH	RO RH_2	R_2O_3 RH_3	RO_2 RH_4	R_2O_5 RH_3	RO_3 RH_2	R_2O_7 RH	RO_4		
Periods	A B	A B	A B	A B	A B	A B	A B	Transition		Series
1	H 1.008									
2	Li 6.941	Be 9.012	B 10.81	C 12.011	N 14.007	O 15.999	F 18.998			
3	Na 22.99	Mg 24.31	Al 26.98	Si 28.09	P 30.97	S 32.06	Cl 35.453			
4 First Series	K 39.10	Ca 40.08	--	Ti 47.90	V 50.94	Cr 52.20	Mn 54.94	Fe 55.85	Co 58.93	Ni 58.69
Second Series	Cu 63.55	Zn 65.39	--	--	As 74.92	Se 78.96	Br 79.90			
5 First Series	Rb 85.47	Sr 87.62	Y 88.91	Zr 91.22	Nb 92.91	Mo 95.94	Tc 98	Ru 101.07	Rh 102.9	Pd 106.4
Second series	Ag 107.87	Cd 112.41	In 114.82	Sn 118.71	Sb 121.76	Te 127.90	I 126.90			
6. First series	Cs 132.90	Ba 137.34	La 138.91	Hf 178.49	Ta 180.95	W 183.84	--	Os 190.2	Ir 192.2	Pt 195.2
Second series	Au 196.97	Hg 200.59	Tl 204.38	Pb 207.2	Bi 208.98					

Fig: Mendeleev's Periodic Table
("R" is used to represent any of the elements in a group)

12.3 MENDELEEV'S CLASSIFICATION OF ELEMENTS

The first successful arrangement of elements was done in 1869 by Russian chemist Dimitri Ivanovich Mendeleev.Mendeleev published a periodic table of elements on the basis of a law called mendeleev's periodic law which states that,

"The physical and chemical properties of elements are the periodic functions of their atomic masses".

ACTIVITY –12.3

Name the elements missing in the Mendeleev's periodic table with atomic masses 44, 68 and 72.To which group do they belong? Is there any group for noble gases?

Characteristics of Mendeleev's Periodic table

- Mendeleev felt that similar properties occurred after periods (horizontal rows) of varying length.
- Mendeleev made an eight-column table of elements.
- He had to leave some blank spaces in order to group all the elements with similar properties in the same column.
- Mendeleev suggested that there must be other elements that had not been discovered.
- He predicted the properties and atomic masses of several elements that were known at that time. Later on, when these elements were discovered their properties remarkably agreed with the predicted one.

For example, He left a gap below silicon in group IV A, and called the yet-undiscovered element as 'Eka silicon'. Discovery of 'Germanium' during his life time proved him correct.

Property	Mendeleev's prediction in 1871	Actual property of Germanium discovered in 1886
1.Atomic Mass	About 72	72.59
2.Specific gravity	5.5 g cm^{-3}	5.47 g cm^{-3}
3.Colour	Dark grey	Dark grey
4.Formula of oxide	EsO_2	GeO_2
5.Nature of chloride	$EsCl_4$	$GeCl_4$

- Similarly Scandium for 'eka-boron' and Gallium for 'eka-aluminium' vacancies were later discovered during his life time.
- Eight out of ten vacant spaces left by Mendeleev were filled by the discovery of new elements.
- Incorrect atomic masses of some arranged elements were corrected. For example, atomic mass of Beryllium as corrected from 13 to 9.

ACTIVITY –12.4

Write down the names of elements belonging to I and II groups in Mendeleev's periodic table.

Group	IA	IB	IIA	IIB
Elements				

ACTIVITY –12.5

Using Mendeleev's periodic table, write the formula of oxides of

1.Lithium, 2. Boron, 3.Sodium, 4.Beryllium, 5. Calcium.

MORE TO KNOW

The difficulty in the Mendeleev's periodic table is overcome by introduction of Modern periodic table. It is also known as Long form of periodic table. In this table, properties of elements are dependent on their electronic configurations (distributions). Hence, modern periodic law is defined as the properties of elements are the periodic function of their atomic numbers.

Modified Mendeleev's periodic table

Groups↓ Periods→	I A B	II A B	III A B	IV A B	V A B	VI A B	VII A B	VIII			0 (ZERO)
1	1.008 H 1										4.003 He 2
2	6.941 Li 3	9.012 Be 4	10.81 B 5	12.011 C 6	14.007 N 7	15.999 O 8	18.998 F 9				20.18 Ne 10
3	22.99 Na 11	24.31 Mg 12	26.98 Al 13	28.09 Si 14	30.97 P 15	32.06 S 16	35.45 Cl 17				39.95 Ar 18
4	39.10 K 19	40.08 Ca 20	44.96 Sc 21	47.90 Ti 22	50.94 V 23	52.20 Cr 24	54.94 Mn 25	55.85 Fe 26	58.93 Co 27	58.69 Ni 28	83.90 Kr 36
	63.55 Cu 29	65.39 Zn 30	69.72 Ga 31	72.61 Ge 32	74.92 As 33	78.96 Se 34	79.90 Br 35				
5	85.47 Rb 37	87.62 Sr 38	88.91 Y 39	91.22 Zr 40	92.91 Nb 41	95.94 Mo 42	98 Tc 43	101.07 Ru 44	102.91 Rh 45	106.4 Pd 46	131.30 Xe 54
	107.87 Ag 47	112.41 Cd 48	114.82 In 49	118.71 Sn 50	121.76 Sb 51	127.90 Te 52	126.90 I 53				
6	132.9 Cs 55	137.34 Ba 56	138.9 La* 57	178.49 Hf 72	180.97 Ta 73	183.84 W 74	186.2 Re 75	190.2 Os 76	192.2 Ir 77	195.2 Pt 78	222 Rn 86
	196.97 Au 79	200.59 Hg 80	204.38 Tl 81	207.20 Pb 82	208.98 Bi 83	209 Po 84	210 At 85				
7	223 Fr 87	226 Ra 88	227 Ac** 90								

6	* Lanthanides	140.12 Ce 58	140.91 Pr 59	144.2 Nd 60	145 Pm 61	150.4 Sm 62	152.0 Eu 63	157.3 Gd 64	158.9 Tb 65	162.5 Dy 66	164.9 Ho 67	167.3 Er 68	168.9 Tm 69	173.0 Yb 70	174.9 Lu 71
7	** Actinides	232.04 Th 90	231 Pa 91	238.02 U 92	237 Np 93	244 Pu 94	243 Am 95	247 Cm 96	247 Bk 97	251 Cf 98	252 Es 99	257 Fm 100	258 Md 101	259 No 102	260 Lr 103

Fig: Modified Mendeleev's periodic table

Characteristics of Modified mendeleev's periodic table

1. Elements are arranged in the increasing order of their atomic masses.
2. Vertical columns are called 'groups' and horizontal rows are called 'periods'.
3. There are 'nine groups' numbered from I to VIII and O.
4. I to VII groups are sub divided into sub groups A and B.
5. There are 'seven periods'.
6. The first three periods contain 2, 8, 8 elements respectively. They are called 'short periods'.
7. The fourth, fifth and sixth periods have 18, 18 and 32 elements respectively.
8. The seventh period is an incomplete period.
9. Blank spaces are left for elements to be discovered.
10. The series of 'fourteen elements' following lanthanum is called 'Lanthanide series'.
11. The series of 'fourteen elements' following actinium is called 'Actinide series'.
12. Lanthanides and actinides are placed at the bottom of the periodic table.

Limitations of modified Mendeleev's periodic table

1. Few elements having a higher atomic mass were placed before elements having a lower atomic mass.

Example: Argon (39.9) was placed before Potassium (39.1)

Cobalt (58.9) was placed before Nickel (58.6)

Tellurium (127.9) was placed before Iodine (126.9)

2. There were no provisions for placing Isotopes.

3. Position of hydrogen in the periodic table was not certain about keeping it with either in group IA or in group VII A.

4. Chemically dissimilar elements were placed in the same group.

For example,

Alkali metals
Sodium
Potassium

were placed along with

Coinage metals
Copper
Silver
Gold

MORE TO KNOW

Gallium is a metal. It has a melting point of 29.8°C. Hence temperature of human body is enough to melt the metal.

12.3.1. METALS AND NON-METALS

All the elements in the periodic table are broadly divided into

- Metals
- Nonmetals
- Semi-metals (Metalloids)

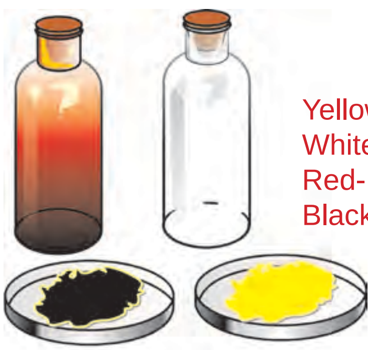
Metals

Metals are shiny if their surfaces are clean. All metals (except mercury) are solids under ordinary conditions of temperature and pressure. Metals usually conduct heat and electricity well and can be rolled or hammered into sheets and pulled into wires. Their chemical properties vary tremendously.

'Gold' and 'Platinum' are used in jewellery because they do not react with water or oxygen in the air. Rubidium not only reacts violently with water but begins to burn if it is exposed to air.

Nonmetals

Elements that do not have the properties of metals are called nonmetals.



Metalloids (Semi-metals)

Elements that have some metallic properties and some nonmetallic properties are called metalloids. They are all solids and look rather like metals.

Eg.Silicon, Germanium.

12.3.2. PHYSICAL PROPERTIES OF METALS AND NON-METALS

1.Physical state

Metals exist in solid state except mercury. Nonmetals may exist in solid, liquid or gaseous state.

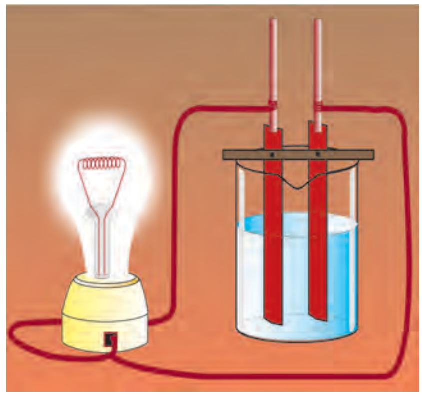
2. Density

Metals have usually high density. Nonmetals are less denser substances.

3. Conductivity

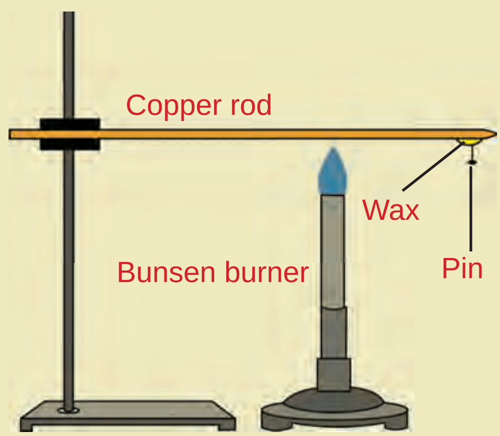
Metals are good conductors of heat and electricity.

Nonmetals are poor conductors or non-conductors of heat and electricity.



ACTIVITY –12.6

- Take a copper rod.
- Clamp this rod on a stand.
- Fix a pin to the free end of the rod using a wax.
- Heat the rod using a Bunsen burner as shown in the figure.
- Observe that, after sometimes, the pin falls down.
- Write down the reason.



4.Metallic Lusture

Metals in pure state, have polished surface and reflect the light falling on the surface producing a characteristic shining.

This property is known as metallic lusture.

Generally non-metals have no lustrous character. However graphite is a nonmetal with lustrous character.

ACTIVITY –12.7

- Take samples of iron, copper, aluminium and magnesium.
- Note the appearance of the sample first.
- Clean the surface of each sample by rubbing them using sand paper.
- Now note the appearance of the sample again.
- Name the elements in the decreasing order of lustrous character.

MORE TO KNOW

- Among metals, silver is the best conductor of electricity.
- Among nonmetals, graphite is the only conductor of electricity.
- Mercury is a metal with a very low melting point and it becomes liquid at room temperature.

5. Malleability

Malleability is the ability of metals to be hammered or squeezed. Hence metals are malleable.

Nonmetals cannot be hammered and hence they are not malleable.

6. Ductility

Ductility is the ability of metals to be pulled or stretched into different shapes. Hence metals are ductile. Nonmetals are non-ductile.

ACTIVITY –12.8

Ductility is the ability of metals to be drawn into thin wires

- Consider iron, magnesium, lead, copper, aluminium and calcium.
- Which of the above metals are also available in the form of wires?

MORE TO KNOW

- Tungsten has the highest melting point of any metal-over 3300^{o}C.
- The lightest metal is lithium. It weighs about half as much as water.
- Osmium is the heaviest metal. It is about 22 times heavier than water and nearly 3 times heavier than iron.

7. Sonority

It is the phenomenon of producing a characteristic sound when a material is struck.

Metals are sonorous in nature.

Nonmetals are nonsonorous.

ACTIVITY –12.9

- Take pieces of iron, copper and aluminium.
- Take one by one and strike it using a hammer several times.
- Observe the sound produced.
- Repeat with other metals.
- Record the sonorous character of these metals.

8. Hardness

Substances with high density are hard, whereas less denser substances are soft.

Metals are hard. Hence they have high melting point except mercury.

Nonmetals have low density and hence they are soft.

12.3.3 CHEMICAL PROPERTIES OF METALS AND NON METALS

1. Action of oxygen(combustion)

(i) Metals

Metals combine with oxygen to form metallic oxides.

Magnesium burns in oxygen to form magnesium oxide.

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

Magnesium burns in oxygen

Aluminium combines with oxygen to form a layer of aluminium oxide.

$$4Al + 3O_2 \longrightarrow 2Al_2O_3$$

Formation of aluminium oxide over a surface of aluminium

Iron wool (threads) burns in oxygen to form iron oxide along with release of thermal energy and light energy.

$$4Fe + 3O_2 \longrightarrow 2Fe_2O_3$$

Iron wool (made into thin fibres) burns in oxygen to produce both heat and light energy

(ii) Non-metals

Sulphur burns in air at 250° C with a pale blue flame to form sulphur dioxide.

$$S + O_2 \longrightarrow SO_2\uparrow$$

Phosphorous burns in air to form phosphorous pentoxide.

$$4P + 5O_2 \longrightarrow 2P_2O_5$$

Carbon burns in air to form carbon monoxide and carbon dioxide.

$$2C + O_2 \longrightarrow 2CO\uparrow$$

$$C + O_2 \longrightarrow CO_2\uparrow$$

ACTIVITY –12.10

Classify the following oxides into acidic or basic oxides.

1. Sodium oxide
2. Zinc oxide
3. Aluminium oxide
4. Carbon dioxide
5. Sulphur dioxide

2. Action of water

(i) Metals

Metals like sodium and potassium react with cold water vigorously and liberate hydrogen gas.

$$2Na + 2H_2O \longrightarrow 2NaOH + H_2\uparrow$$

$$2K + 2H_2O \longrightarrow 2KOH + H_2\uparrow$$

Magnesium and Iron react with steam to form magnesium oxide and iron oxide respectively. Hydrogen is liberated.

$$Mg + H_2O \longrightarrow MgO + H_2\uparrow$$

$$3Fe + 4\,H_2O \longrightarrow Fe_3O_4 + 4\,H_2\uparrow$$

Aluminium slowly reacts with steam to form aluminium hydroxide and hydrogen.

$$2Al + 6\,H_2O \longrightarrow 2Al\,(OH)_3 + 3\,H_2\uparrow$$

Other metals like copper, nickel, silver, gold have no reaction with water.

(ii) Nonmetals

Carbon reacts with water to form carbon monoxide and hydrogen.

$$C + H_2O \longrightarrow CO\uparrow + H_2\uparrow$$

3. Action of acids on metals

Metals such as sodium, magnesium, aluminium react with dilute hydrochloric acid and liberate hydrogen gas.

$$Mg + 2HCl \longrightarrow MgCl_2 + H_2\uparrow$$

$$2Al + 6HCl \longrightarrow 2AlCl_3 + 3H_2\uparrow$$

ACTIVITY –12.11

- Take 10 ml of dilute hydrochloric acid in a test tube.
- Add a small piece of iron into it.
- Observe the changes.

4. Action of chlorine

(i) Metals

Metals like sodium, calcium react with chlorine to form their chlorides.

$$2Na + Cl_2 \longrightarrow 2NaCl$$

$$Ca + Cl_2 \longrightarrow CaCl_2$$

(ii) Nonmetals

Sulphur reacts with chlorine to form sulphur mono chloride.

$$2S + Cl_2 \longrightarrow S_2Cl_2$$

5. Action of hydrogen

(i) Metals

Very few metals like sodium, potassium, calcium react with hydrogen to form their hydrides.

$$2Na + H_2 \longrightarrow 2NaH$$

$$Ca + H_2 \longrightarrow CaH_2$$

(ii) Nonmetals

Sulphur reacts with hydrogen to form hydrogen sulphide which has characteristic rotten egg odour.

$$S + H_2 \longrightarrow H_2S\uparrow$$

Carbon reacts with hydrogen in the presence of electric arc to form acetylene.

$$2C + H_2 \longrightarrow C_2H_2\uparrow$$

12.3.4 REACTIVITY SERIES

In single – replacement reactions, one element takes the place of another element in a compound. Very reactive metals react with water at room temperature. The reactive metal, takes the place of hydrogen in water.

At room temperature, sodium reacts with water more vigorously.

$$2Na + 2H_2O \longrightarrow 2NaOH + H_2\uparrow$$

Calcium reacts with water slowly.

$$Ca + 2H_2O \longrightarrow Ca(OH)_2 + H_2\uparrow$$

Magnesium does not react with water.

$$Mg + H_2O \longrightarrow \text{No reaction}$$

These observations lead to the conclusion that the order of reactivity of these metals towards water is,

Na > Ca > Mg

ACTIVITY –12.12

Reactivity series of metals:

Potassium(K)	These metals react with water
Sodium(Na)	
Calcium(Ca)	
Magnesium(Mg)	These metals react with dilute acids.
Aluminium(Al)	
Manganese(Mn)	
Zinc(Zn)	
Chromium(Cr)	
Iron(Fe)	
Nickel(Ni)	
Tin(Sn)	
Lead(Pb)	
Copper(Cu)	These metals do not react with dilute acids.
Silver(Ag)	
Gold(Au)	

MORE TO KNOW

Reactivity of metals appears to decrease from left to right across a period in the periodic table and reactivity increases from top to bottom of a group in the periodic table.

12.3.5 USES OF REACTIVITY SERIES

1. Metals which react with water are placed first in the reactivity series.
2. Metals at the beginning of the series react with dilute acids.
3. Metals at the bottom of the series do not react with water.
4. Metals at the bottom of the series do not react with dilute acids.
5. Metals in the middle of the series react with dilute acids.
6. Metals upper in the reactivity series displace the metals in the bottom of the series.

12.3.6 ALLOYS

The idea of making alloys is not new. It was known by people in ancient times. Thousands of years ago, people discovered that they could use copper instead of stone to make their tools. About 3500 B.C. it was found that if tin, a fairly soft metal was combined with copper, a very hard material was produced. This material was the alloy called "bronze". Bronze was a better material for many purposes than either of the two metals that composed it.

Alloys are homogeneous mixture consisting of two or more metals fused together in the molten state in fixed ratios.

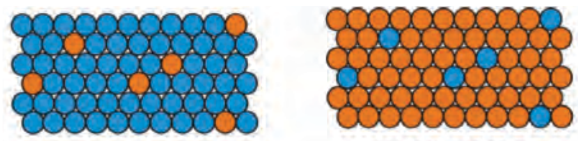
Composition of Alloys

There are two types of alloys. They are,

(i) Substitutional alloys

(ii) Interstitial alloys

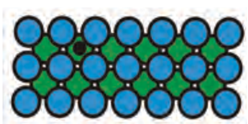
In substitutional alloys, atoms of one metal randomly take the place of atoms of another metal.



90% Ni - 10% Cu   10% Ni - 90% Cu

● =Ni   ● =Cu

Substitutional alloy



● = Fe in top layer

● = Fe in second layer

● = Carbon

Interstitial alloy

In interstitial alloys, small non-metallic atoms such as H(Hydrogen), B(Boron), C(Carbon) and N(Nitrogen) occupy the holes in the crystal structure of the metal.

Types of alloys:

There are two types of alloys. They are,

- Ferrous alloys - contain iron as base metal.
- Non-ferrous alloys - contain a little or no iron.

MORE TO KNOW

Alnico are alloys of Iron, Aluminium and Nickel and Cobalt. Alnico are used to make magnets, up to 25 times as strong as ordinary magnets.

12.3.7 USES OF ALLOYS

Name	Composed of	Uses
Brass	Copper Zinc	Screws, windows and door fittings
Bronze	Copper Tin	Statues, machine parts
Solder	Tin Lead	In electrical and plumbing industries to join metal surfaces without melting them.
Steel	Iron, Carbon, Chromium, Nickel, Tungsten	Construction of bridges, buildings, household products, cooking utensils
Duralumin	Aluminium, Copper Manganese, Magnesium	Aircraft parts, cars, ships and nails.

Characteristics of alloy

1. It enhances the hardness of metal.
2. It enhances the tensile strength of the base metal.
3. It improves corrosion resistance.
4. It modifies the colour.
5. It provides better castability.

MORE TO KNOW

Amalgam is an alloy in which one of the constituents is mercury.

12.3.8. NANO SCIENCE

Nanoscience is the study of atoms, molecules and objects whose size is on the nanometre scale (1-100 nm).

1 nanometre = 10^{-9} metre

Nanotechnology

- It involves making ultra-small devices .
- They are about a nanometre.
- One nanometre is equal to one billionth of a metre in length.
- It is roughly the size of ten atoms placed end to end.

Objective of nanotechnology

When the size of the matter is reduced to a few nanometers, there is an increase in surface area. The increased surface area assumes a critical role such as in "chemical catalysis".

Applications of nanotechnology

- Tiny computers can be produced, which are many times faster than ordinary ones.
- It is used to make miniature pumps,which are useful in medical field.
- Nanostructured materials are used as catalysts to improve the efficiency of batteries.
- It makes a significant contribution to the fields of semiconductors and biotechnology.
- It converts a particular wavelength of light into heat.
- It finds use in the treatment of cancer.
- It is used in textile industry to provide better stain-resistance in fabrics.
- It is useful to reduce the degradation of food and vegetables.

EVALUATION

Section A

Choose the correct answer

1. Classification of elements into two divisions namely metals and non-metals was firstly attempted by______________(Dobereiner, Lavoisier, Mendeleev).

2. As per Newland's 'Law of octaves' which of the two elements in the given table have repetition of similar properties.

1	2	3	4	5	6	7	8
Na	Mg	Al	Si	P	S	Cl	K

3. In Mendeleev's periodic table, all the elements are sorted in the periodic functions of their ___________ (Mass number, Atomic number)

4. One of the coinage metals is ___________ (Copper, Sodium, Nickel)

5. Liquid metal at room temperatrue is (Mercury, Bromine, Tin)

6. Osmium is the heaviest metal. It is ___________ (22½, 3, about half) times heavier than iron.

7. Metalloids have some metallic properties and some nonmetallic properties. An example for metalloid is____________ (Silicon, Argon, Iodine)

8. Complete $Mg+O_2 \longrightarrow$?

9. Sodium reacts with water and gives sodium hydroxide and _____________ (O_2, H_2, Cl_2)

10. Sulphur reacts with hydrogen to give hydrogen sulphide. The odour of hydrogen sulphide is ___________ (rotten egg, pleasant)

11. Arrange the following elements in the ascending order, based on their reactivity. Na, Ca, Mg

12. Bronze is an alloy of ____________ (copper and tin, silver and tin, copper and silver)

13. An alloy used in manufacturing Aircraft parts is ________________ (solder, brass, duralumin)

14. The technology that is useful to reduce the degradation of food and vegetables is ____________(Nano technology, biotechnology, genetic engineering)

Section B

15. Mendeleev's periodic table is constructed into vertical columns and horizontal rows.
    a. Mention the name of vertical columns
    b. Mention the name of horizontal rows.

16. In the periodic table the position of hydrogen was not certain. Give reason.

17. Pick the odd one out.
    a. Coins, Brass, Copper, Gold ornaments
    b. Bromine, Carbon, Hydrogen, Aluminium

18. What is an alloy? Give one example.

19. $2Na + Cl_2 \longrightarrow 2NaCl$
    a. Name the product.
    b. Name the colour of Cl_2 gas.

20. Mention the objective of nano science.

Section C

21. Mendeleev arranged elements in periods and groups.
    a. Total number of periods in modified periodic table
    b. Total number of groups in modified periodic table
    c. Number of elements in first period
    d. Mention the incomplete period
    e. Where are the Lanthanides and Actinides placed?
22. Answer the following
    a. Metals are sonorous in nature. But non-metals are non-sonorous . Give reason.
    b. Which is the most ductile and malleable metal?
    c. Metals are good conductors of heat and electricity. Can you say the metal which is the best conductor of electricity?
    d. Metals are hard. Non metals are soft. Give reason.
23. Answer the following
    a. Aluminium reacts with oxygen to form a layer. Write the name and chemical formula of the layer.
    b. Sodium reacts with water to form sodium hydroxide. But magnesium does not react with water. Give reason.
    c. P_2O_5 is acidic or basic?
24. Answer the following
    a. Mention any two applications of nanotechnology?
    b. Name the alloy that is used to make statues.
    c. Write the composition of solder.

FURTHER REFERENCE

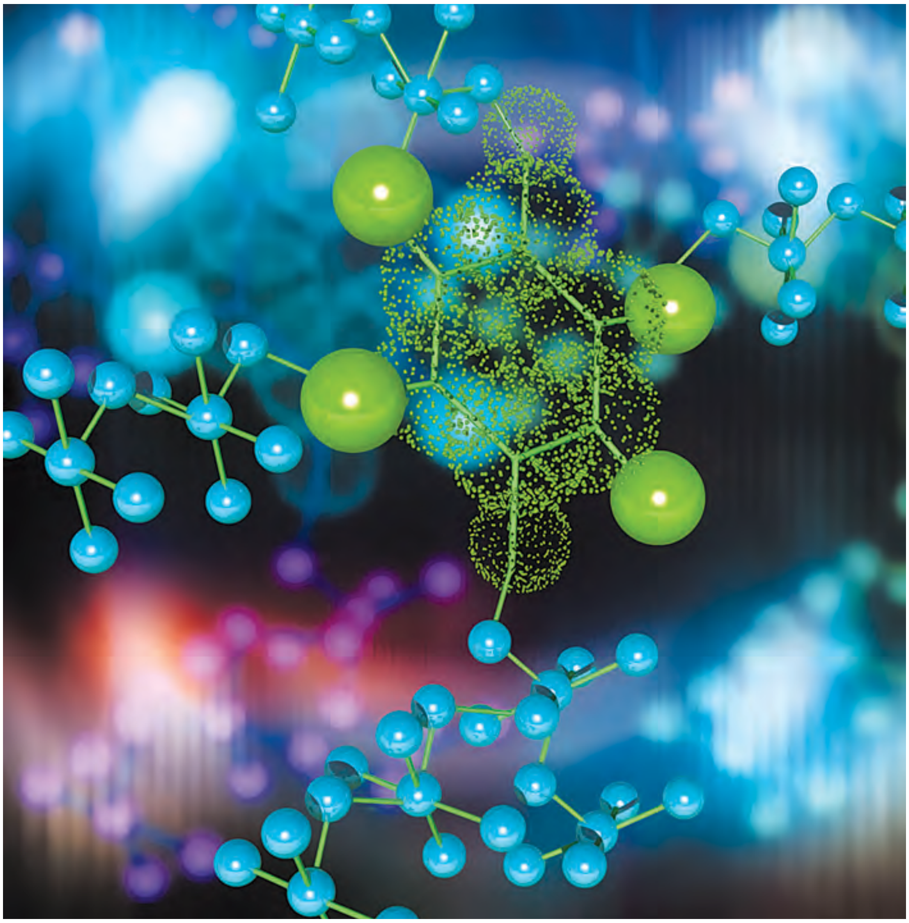
Book

ext book of Inorganic chemistry - P.L. Soni
Sultan chand & Sons

Websites

http://www.chymist.com
http://www.khanacademy.org

Chapter 13



CHEMICAL BONDS

13. CHEMICAL BONDS

In a garland, the flowers are tiedup by means of a thread. Unless the flowers are tied, they cannot be held together. The role of thread is to hold all the flowers together. It is more or less equivalent to a bond.

Molecules of chemical substances are made of two or more atoms joined together by some force acting between them. This force which results from the interaction between the various atoms that forms a stable molecule is referred to as the chemical bond.

A chemical bond is defined as a force that acts between two or more atoms to hold them together as a stable molecule.

13.1 OCTET RULE

Gilbert Newton Lewis used the knowledge of electronic configuration of elements to explain "why atoms joined to form molecules". He visualized that inert (noble) gases have a stable electronic configuration, while atoms of all other elements have unstable or incomplete electronic configuration.

In 1916, G.N.Lewis gave the "electronic theory of valence". This electronic theory of valence could well be named as the "octet theory of valence".

Atoms interact by either electron-transfer or electron-sharing, so as to achieve the stable outer shell of eight electrons. This tendency of atoms to have eight electrons in the outer shell is known as "octet rule" or "Rule of eight".

ACTIVITY –13.1

Which among the following elements share or transfer electrons to obey octet rule?

1. Helium
2. Argon
3. Lithium
4. Chlorine

MORE TO KNOW

Elements with stable electronic configurations have eight electrons in their outermost shell. They are called inert gases.

Ne (Atomic number 10) = 2, 8 and Ar (Atomic number 18) = 2, 8, 8

ACTIVITY –13.2

The following elements have no stable electronic configuration. Write the electron distribution.

Element	Atomic number	Electron distribution
Sodium		
Carbon		
Fluorine		
Chlorine		

MORE TO KNOW

Lewis used dot-symbols to represent the valence electrons which make bonds.

Lewis Symbol	Electron distribution	Valence electrons
H·	(1)	1
·Be·	(2,2)	2
·B·	(2,3)	3
·C·	(2,4)	4
·N·	(2,5)	5

13.2 TYPES OF CHEMICAL BOND

Scientists have recognized three different types of bonds.

They are,

- Ionic or electrovalent bond
- Covalent bond
- Co-ordinate covalent bond

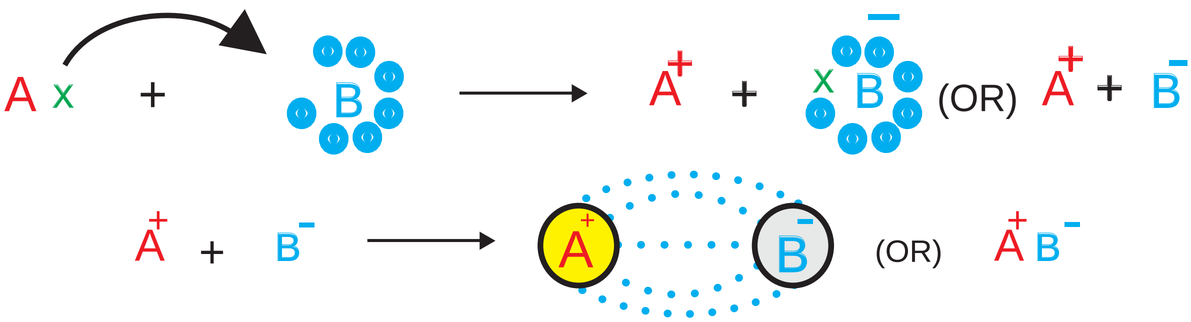
MORE TO KNOW

Electrostatic attraction is found between oppositively charged ions. It is also known as coulombic force of attraction.

13.3 FORMATION OF IONIC AND COVALENT BOND

1. Formation of ionic (or) electrovalent bond

Let us consider two atoms A and B. The atom A has 1 electron in its valence (outermost) shell.B has 7 electrons in its valence shell. Hence A has 1 electron excess and B has 1 electron lesser than the stable octet configuration. Therefore, A transfers an electron to B.In this transaction both the atoms A and B acquire a stable electron-octet configuration. A becomes a positive ion (cation) and B becomes a negative ion (anion). Both the ions are held together by electrostatic force of attraction. Formation of ionic bond between A and B can be shown as,



Thus electrostatic attraction between cation (+) and anion (-) produced by electron transfer constitutes an ionic or electrovalent bond. The compounds containing such a bond are referred to as “Ionic or electrovalent compounds”.

ACTIVITY –13.3

The atom which gives off electron becomes cation and which accepts electron becomes anion. Which atoms do form cations or anions?

1. Lithium	3. Fluorine
2. Sodium	4. Chlorine

Conditions favourable for the formation of ionic bond

(i) Number of valence electrons

The atom A should possess 1, 2 or 3 valence electrons while the atom B should have 5, 6 or 7 valence electrons.

(ii) Net lowering of energy

To form a stable ionic compound, there must be a net lowering of energy. In other words, energy must be released as a result of electron transfer from one atom to another.

(iii) Attraction towards electrons

Atoms A and B should differ in their attracting powers towards electrons.

A has less attraction of electrons and hence gives off the electron while B has more attraction towards electron and hence gains electrons.

MORE TO KNOW

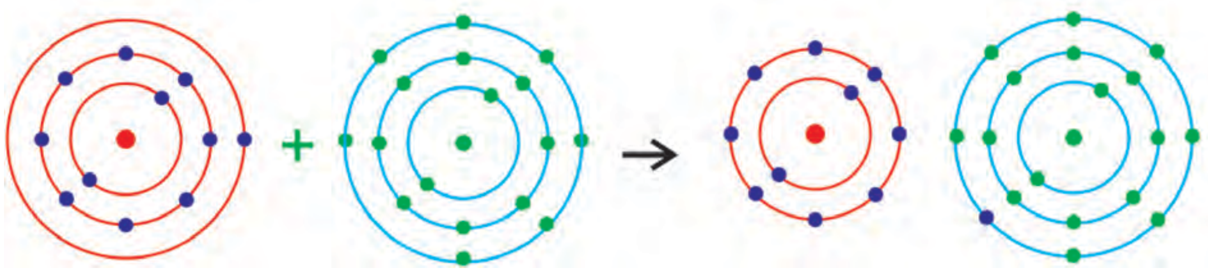
Attracting power of bonded pair electrons by an atom is known as electro negativity. Atom with more attraction towards bonded electrons is called more electronegative element and lesser attraction towards bonded electrons is known as lower electronegative element.

<u>Illustration: 1</u>

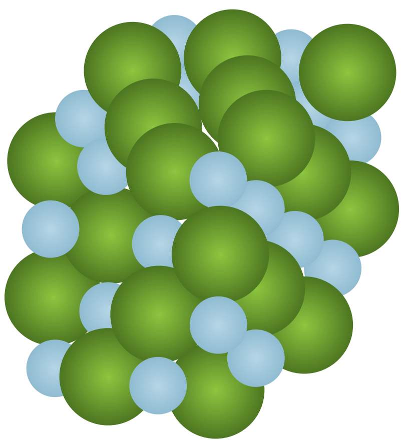
Formation of Sodium chloride

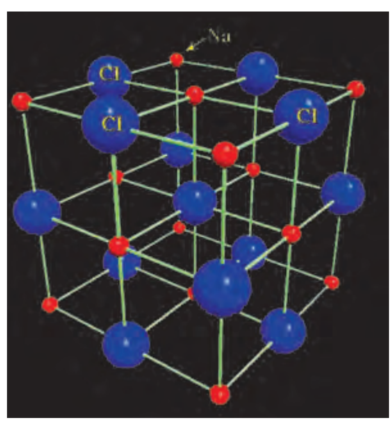
Sodium chloride is formed from an atom of sodium and one atom of chlorine. Electronic configuration of Na atom=2, 8, 1 (Atomic number 11)

Electronic configuration of Cl atom=2, 8, 7 (Atomic number 17).Sodium transfers its one valence electron to chlorine and both achieve stable electron octet configurations. Hence sodium (Na) becomes, sodium cation (Na^+) and Chlorine (Cl) becomes chloride anion (Cl^-) both the ions are joined together by electrostatic force of attraction to make an ionic bond. In the Crystalline state, each Na^+ ion is surrounded by 6 Cl^- ions and each Cl^- ion is surrounded by 6 Na^+ ions.



2,8,1 Sodium atom (Na) | 2,8,7 Chlorine atom (Cl) | 2,8 Sodium cation (Na^+) | 2,8,8 Chloride anion (Cl^-)





Structure of sodium chloride

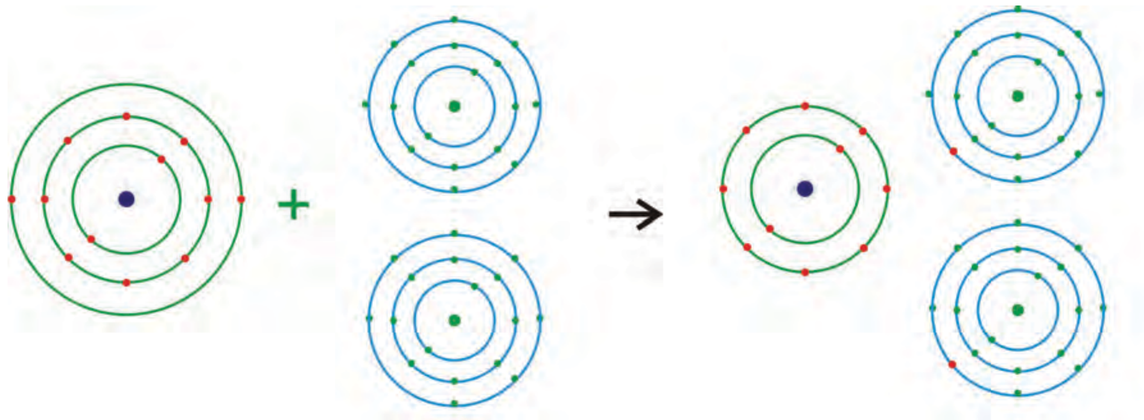
Illustration: 2

Formation of Magnesium chloride

Atoms	Atomic number	Electron distribution
Magnesium	12	2,8,2
Chlorine	17	2,8,7

Magnesium has 2 valence electrons while chlorine has 7 valence electrons. Magnesium atom transfers 2 electrons one to each chlorine atom and thus all the three atoms achieve the stable octet electronic configuration.

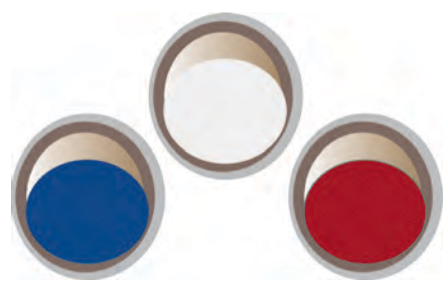
Magnesium atom becomes Mg^{2+} ion and the 2 chlorine atoms become 2 Cl^{-} ions forming Magnesium chloride as $MgCl_2$.



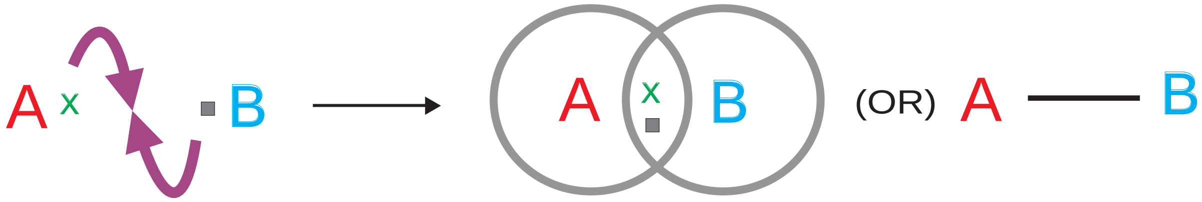
2,8,2 Magnesium atom | 2,8,7 Chlorine atom | 2,8 Magnesium cation | 2,8,8 Chloride anion

2. Formation of Covalent bonds

G.N.Lewis suggested that two atoms could achieve stable 2 or 8 electrons in the outer shell by sharing electrons between them. Atom A has 1 valence electron and atom B has 1 valence electron. As they approach each other, each atom contributes one electron and the resulting electron pair fills the outer shell of both the atoms.



Blue - copper sulphate
White - sodium chloride
Red - cobalt chloride
} Ionic compounds



Thus a shared pair of electrons contributes a covalent bond or electron pair bond.

The compounds containing a covalent bond are called covalent compounds.

Conditions for formation of covalent bond

Number of valence electrons

Each of the combining atoms A and B should have 5, 6 or 7 valence electrons so that both the atoms achieve the stable octet electronic configuration by sharing 3, 2 or1 electron pair.

Equal electron attraction

Both the atoms A and B should exhibit nearly equal attraction towards bonded pair of electrons, ie. equal electronegativity.

Equal sharing of electrons

Both the atoms A and B should have nearly equal attraction towards bonded electron pair.

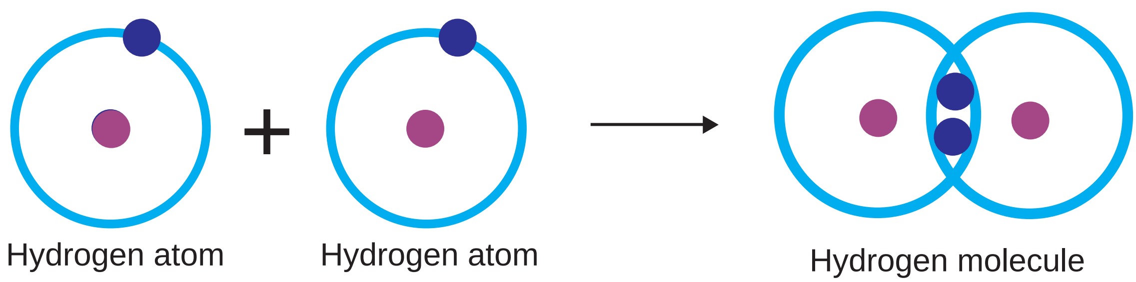
MORE TO KNOW

Multiple bonds enable more atoms to achieve an octet electronic configuration.

<u>Illustration: 1</u>

Formation of hydrogen molecule

Hydrogen molecule is made up of two hydrogen atoms. Each hydrogen atom has one valence electron. Each hydrogen atom contributes an electron to the shared pair and both the atoms attain stable electronic configuration.



<u>Illustration: 2</u>

Formation of chlorine molecule

Each chlorine atom (2, 8, 7) has seven valence electrons. Each of them share an electron and attain stable electronic configuration.

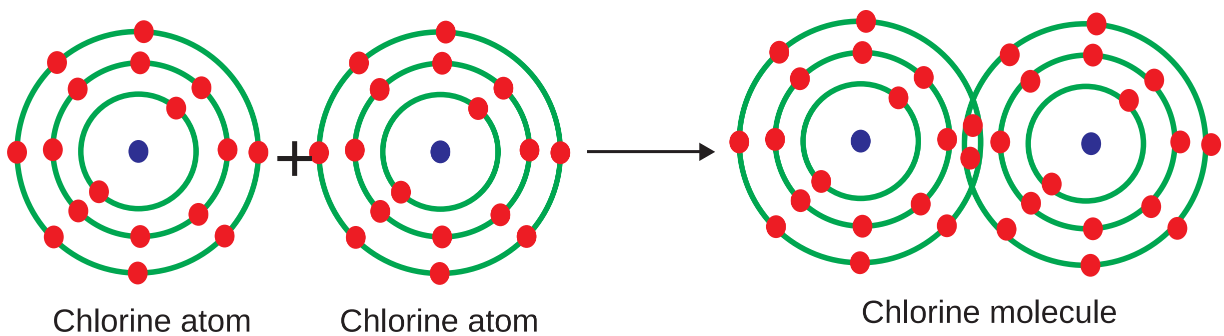
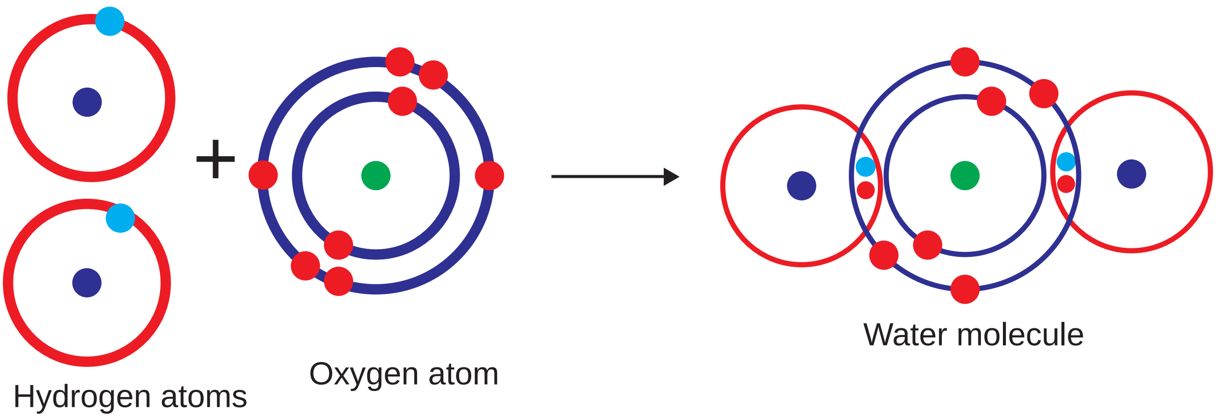
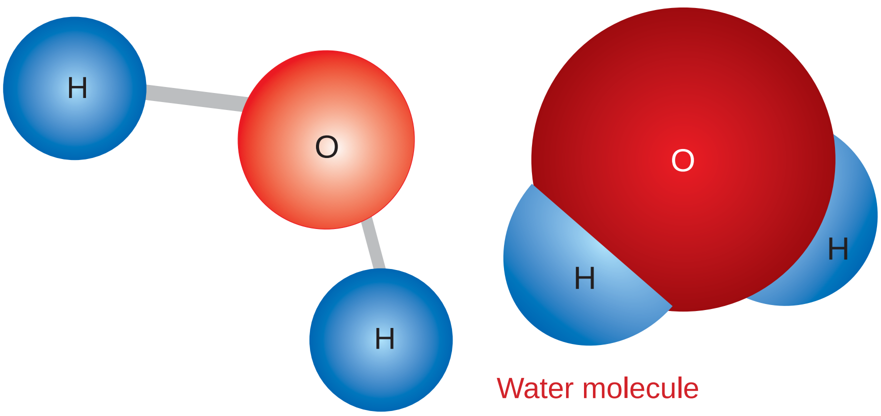


Illustration: 3

Formation of water molecule

Oxygen atom (2, 6) has six valence electrons. Hydrogen atom has one valence electron each. Oxygen atom shares two electrons one each with two hydrogen atoms.





Water molecule

MORE TO KNOW

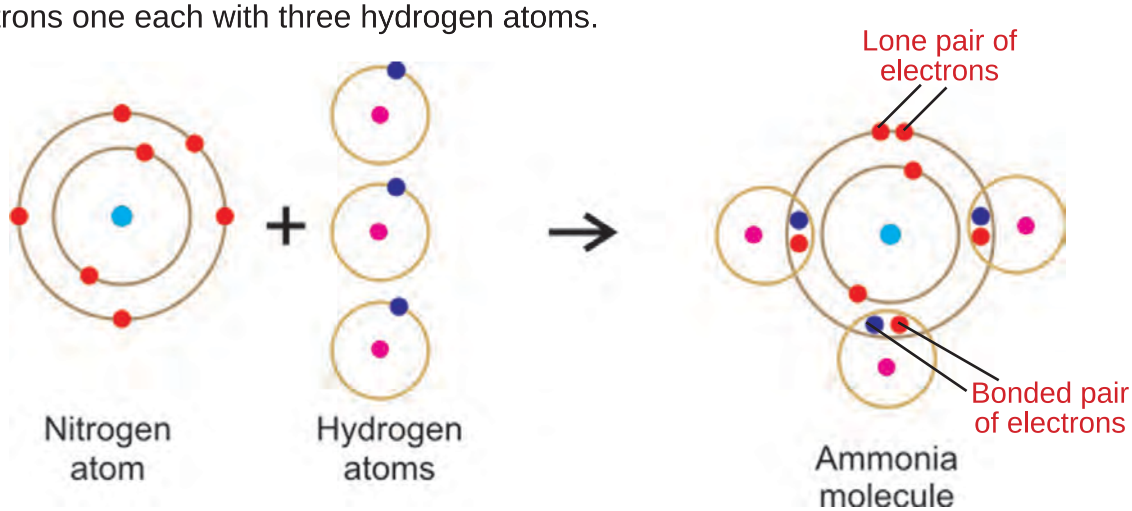
Lone pair of electrons are the electrons, that are not involved in bond formation.

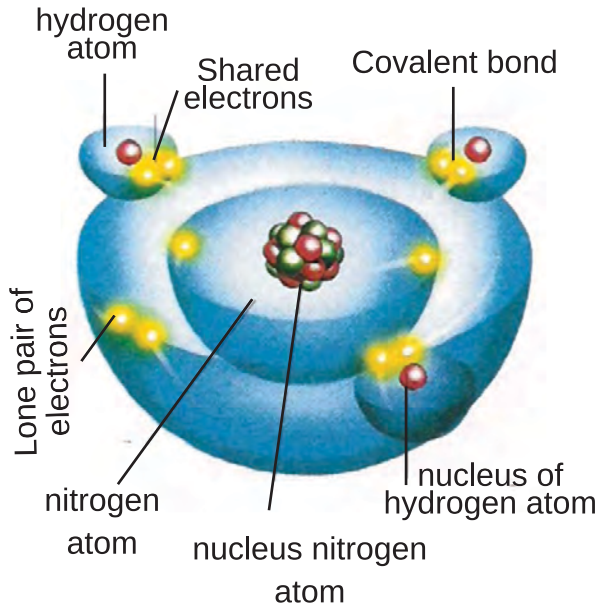
Illustration: 4

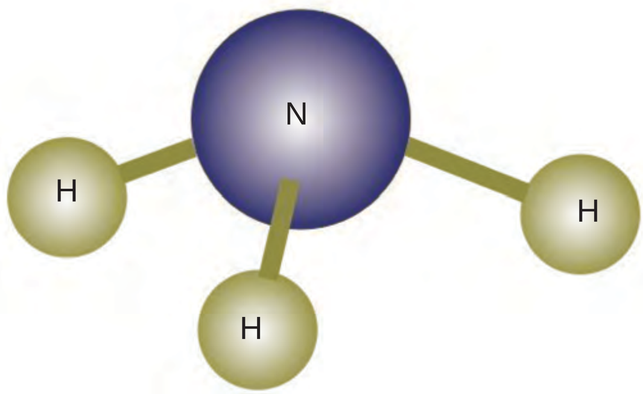
Formation of ammonia molecule

Nitrogen atom (2, 5) has five valence electrons.

Hydrogen atom has one valence electron each. Nitrogen atom shares three electrons one each with three hydrogen atoms.







Ammonia molecule

ACTIVITY –13.4

Write the Lewis formula and predict the number of covalent bonds in

1. Chlorine
2. Ammonia
3. Fluorine

13.3.1. COMMON PROPERTIES OF IONIC COMPOUNDS

Solids at room temperature

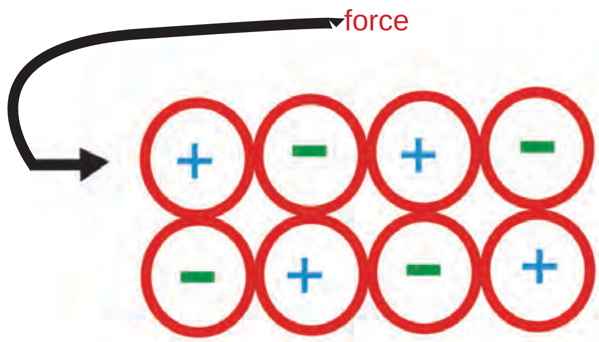
On account of strong electrostatic force between the opposite ions, these ions are not in a free movement. Hence ionic compounds are solids at room temperature.

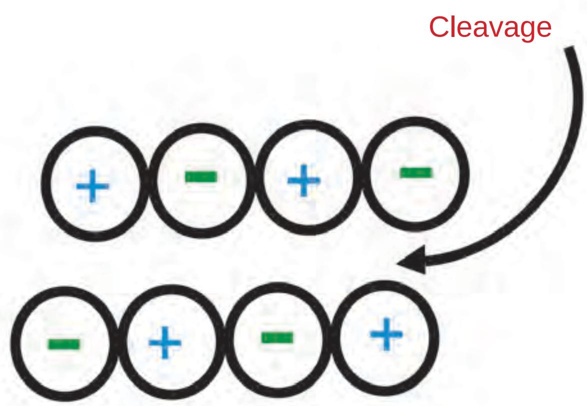
High melting point

Since the (+) and (-) ions are tightly held in their positions, only at high temperature, these ions acquire sufficient energy to overcome the attractive force causing movement. Hence ionic compounds have high melting point.

Hard and brittle

Their hardness is due to strong electrostatic force of attraction. When external force is applied slight shift takes place bringing like-ions in front of each other. It causes repulsion and cleavage occurs.



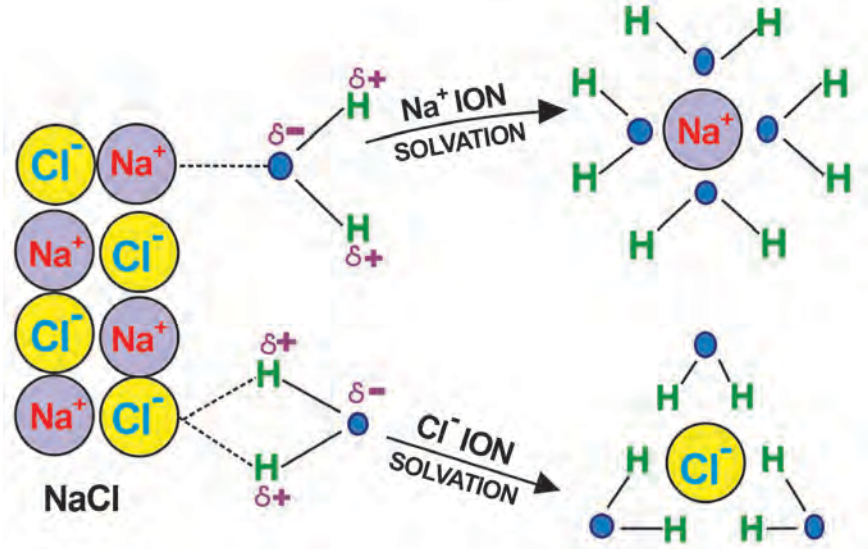


MORE TO KNOW

Refractory materials are heat resistant materials. They have very high melting points. They are used in the extraction of metals from their ores. Some refractory materials are ionic compounds.

Soluble in water

When a crystal is put in water, the polar water molecules separate the (+) and (-) ions making the crystal soluble.



ACTIVITY –13.5

1. Take two beakers.
2. Take little water in one beaker and little kerosene in another beaker.
3. Add sodium chloride salt to each of the beakers.
4. Observe the solubility.

Conductors of electricity

In the solid state, the ions are fixed in their positions. Hence they are poor conductors of electricity. In molten stage and in water solutions, the ions are free to move. Hence they conduct electricity in molten state or in aqueous solutions.

Ionic reactions are fast

Ionic compounds give reactions between ions. Hence their reactions are fast.

13.3.2. COMMON PROPERTIES OF COVALENT COMPOUNDS

Gases, liquids or solids at room temperature

Due to weak intermolecular forces between the molecules, covalent compounds exist as gases, liquids or relatively soft solids.

Low boiling point

In solids, the molecules are held by weak forces of attraction. When heat is applied the molecules are readily pulled out and get free movement as in liquid.

Soft solids

A molecular layer in the crystal easily slips relative to adjacent layers. Thus the crystals are easily broken.

Soluble in organic solvents

These compounds readily dissolve in non-polar solvents like toluene, benzene etc.The solvent molecules easily overcome the weak inter molecular forces of attraction.

MORE TO KNOW

Bonds in which electron pairs are equally shared are non-polar bonds. Bonds in which electron pairs are not equally shared are polar bonds.

ACTIVITY –13.6

Classify the following solvents into polar and non-polar.

1. Benzene 3. Ether
2. Water 4. Chloroform

Non-conductors of electricity

Since there are no (+) and (-) ions in covalent molecules, they are not capable of conducting electricity in molten state or in solution state.

Molecular reactions are slow

In reaction of covalent compounds, the molecules as a whole undergo a change. There is no electrical force to speed up the reactions. Hence these reactions are slow.

ACTIVITY –13.7

- Take sodium chloride and paraffin wax.
- Take two solvents namely water and turpentine in separate beakers.
- First add sodium chloride to both the solvents and note the solubility.
- Then add paraffin wax to both the solvents separately in another beakers and note the solubility.
- Differentiate the solubility.

13.4 DIFFERENCES BETWEEN IONIC AND COVALENT COMPOUNDS

Ionic bond	Covalent bond
Formed by transfer of electrons from a metal to a non-metal atom.	Formed by sharing of electrons between non-metal atoms.
Consists of electrostatic force of attraction between (+) and (-) ions.	Consists of weak force of attraction between atoms.
Non-rigid and non-directional	rigid and directional
Properties of compound	**Properties of compound**
Solids at room temperature	Gases, liquids or soft solids at room temperature.
Has high melting and boiling points.	Has low melting and boiling points.
Hard and brittle.	Soft, much readily broken.
Soluble in polar solvents and insoluble in organic solvents.	Soluble in non-polar solvents and insoluble in polar solvents.
Conductor of electricity in molten or solution state.	Non-Conductor of electricity in molten or solution state.
Undergoes ionic reactions which are fast.	Undergoes molecular reactions which are slow.

13.5 COORDINATE COVALENT BOND

In a normal covalent bond, each of the two bonded atoms contributes one electron to make the shared pair. In some cases, a covalent bond is formed when both the electrons are supplied entirely by one atom. Such a bond is called coordinate covalent or dative bond.

Thus coordinate covalent bond is a covalent bond in which both the electrons of the shared pair come from one of the two atoms or ions. The compounds containing a coordinate bond are called coordinate compounds.

MORE TO KNOW

Sharing of two pairs of electrons make a double bond. Sharing of three pairs of electrons make a triple bond. These are called multiple covalent bonds.

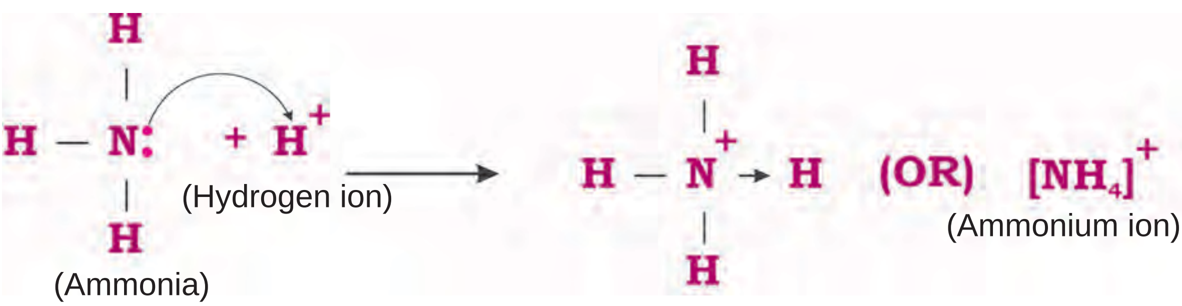
1. Carbon dioxide O=C =O (two double bonds)
2. Oxygen O=O (one double bond)
3. Nitrogen N≡N (one triple bond)

If an atom 'A' has an unshared pair of electrons (lone pair) and another 'B' is short of two electrons, then a coordinate bond is formed. 'A' donates the lone pair (2 electrons) to 'B' which accepts it.

Illustration

Ammonium ion (NH_4^+)

Ammonium ion is formed by the addition of hydrogen ion (H^+) with ammonia (NH_3). In ammonia molecule, the central nitrogen atom is linked to three hydrogen atoms and yet nitrogen has an unshared pair of electrons. Nitrogen donates this lone pair of electrons to hydrogen ion of an acid forming ammonium ion.

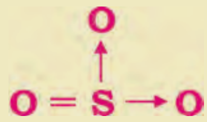


MORE TO KNOW

Under ordinary conditions of temperature and pressure, carbon dioxide is a gas because molecules of carbon dioxide are non-polar.

Water is a liquid as a result of the great polarity of water molecules

ACTIVITY –13.8

Sulphur tri oxide (SO_3) has the structure, 

How many coordinate linkages are present in this molecule? Identify the acceptor and donor atoms.

ACTIVITY –13.9

Carbon monoxide is a gas. It is a coordinate compound.

Structure of carbon monoxide is 

Identify the donor and acceptor atoms.

13.5.1. COMMON PROPERTIES OF COORDINATE COMPOUNDS

Conductors of electricity

They do not give individual ions in water and are poor conductors of electricity.

Soluble in organic solvents

They are sparingly soluble in water and dissolve in organic solvents.

Melting and boiling points

They are semi polar in nature. They possess melting and boiling points higher than those of purely covalent compounds, but lower than ionic compounds.

Exceptions to the Octet Rule

It is true that quite a few molecules had non-octet structure. Atoms in these molecules could have a number of electrons in the valence orbit short of the octet or in excess of the octet.

(i) Four electrons around the central atom

Berylliumdichloride ($BeCl_2$)

	Beryllium	Chlorine
Atomic number	4	17
Electron distribution	2,2	2,8,7
Valence electrons	2	7

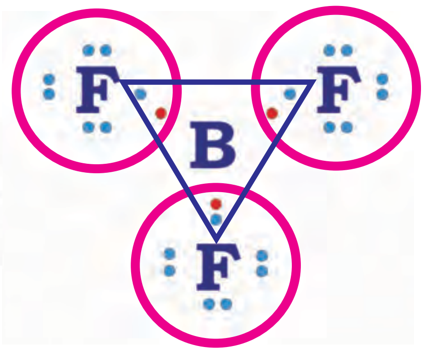
Each chlorine atom is surrounded by 8 electrons but beryllium atom has only 4 electrons around it.

(ii) Six electrons around the central atom

Borontrifluoride (BF_3)

	Boron	Fluorine
Atomic number	5	9
Electron distribution	2,3	2,7
Valence electrons	3	7

Each fluorine atom is surrounded by 8 electrons but boron atom has only 6 electrons around it.



ACTIVITY –13.10

Atomic number of phosphorous is 15.Write the electron distribution in phosphorous. Atomic number of chlorine is 17.Write the electron distribution of chlorine. One phosphorous atom combines with five chlorine atoms to form phosphorous penta chloride (PCl_5).Which atom will have the octet?

EVALUATION

Section A

Choose the correct answer

1. As per the Octet rule, noble gases are stable in nature. This is due to the presence of _________ (eight, seven, six) electrons in their outermost shell.
2. The element that would form cation due to loss of electron during the chemical reaction is _________ (chlorine, lithium, fluorine)
3. Atomic number of magnesium is 12. Then its electron distribution is _________ (2,2,8 / 2,8,2 / 8,2,2)
4. An element X has 6 electrons in its outermost shell. Then the number of electrons shared by X with another atom to form covalent bond is _________ (3, 2, 6)
5. The compound that possess high melting point is _________ (NH_3, NaF)
6. Bond in which the electron are equally shared is _________ (polar bond, non polar bond, ionic bond)

7. Pickout the wrong statement about the properties of covalent compounds.

   a) They are neither hard nor brittle.

   b) Molecular reactions are fast.

Section B

8. NaCl is an Ionic compound. How is an ionic bond formed?

9. All the elements tend to attain eight electrons in their outer most shell either by sharing or transfer of electron. From the electronic distribution of the following, which one undergoes loss of electron or sharing of electrons.

   X = 2, 7 Y = 2, 8, 1

10. $MgCl_2$ is a solid compound. It does not conduct electricity in solid state. When it is in molten state it conducts electricity. Find the reason.

Section - C

11. $$\underset{(2,8,1)}{Na} + \underset{(2,8,7)}{Cl} \longrightarrow \underset{(2,8)}{Na^+} + \underset{(2,8,8)}{Cl^-} \longrightarrow Na^+Cl^-$$

    The above equation represents the formation of sodium chloride. Observe the above equation and answer the following.

    (a) How many electrons are transferred from Na to Cl?

    (b) Name the force acting between Na^+ and Cl^-.

    (c) Name the nearest noble gas to Cl^-

    (d) Name the bond between Na^+ and Cl^-

    (e) How many electrons are present in Na^+ ion?

12. Ammonia molecule is formed by the sharing of electrons between Nitrogen and hydrogen. For the molecules of ammonia., answer the following.

    (a) State whether ammonia is a covalent or ionic molecule.

    (b) Number of covalent bonds between N and H

    (c) Does ammonia conduct electricity

    (d) Draw the structure of ammonia

FURTHER REFERENCE

Book

Essentials of Physical Chemistry - B.S.Bahl,G.D.Tuli,Arun Bahl.
S. Chand & Company Ltd

Websites

http://www.beyondbooks.com

http://www. visionlearning.com

Chapter 14

MEASURING INSTRUMENTS

MEASURING INSTRUMENTS

Kannan and his father went to market to buy nylon ropes for their house. They left home by 5:05:00 p.m and reached the shop by 5:23:39 p.m. That is they took 18 minute and 39 second to reach the shop from home. Kannan's digital watch was used to verify the time taken. Now they asked for twenty metre rope from the shopkeeper. The shopkeeper took the rope and weighed 375 gram using digital balance.

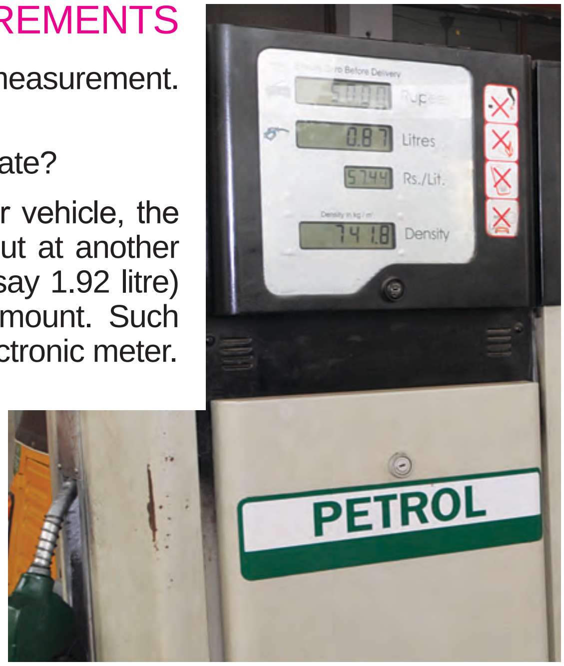
Thus measurement is an integral part of our day-to-day life. Let us see how various things are measured.

14.1. CONCEPTOFSMALLMEASUREMENTS

Physics is based on the study of systematic measurement. It is necessary to measure things accurately.

Why should measurements be made accurate?

When we fill petrol at a petrol bunk for our vehicle, the meter may stop at two digits (say 1.9 litre), but at another bunk, it may show a reading of three digits (say 1.92 litre) which is the actual quantity for the same amount. Such accurate measurement is possible with an electronic meter.



14.2. MEASURING LENGTH

In a laboratory, a small metre scale is used to measure the length of any object. In a metre scale, the smallest length that can be measured is 1 mm. This is called the Least Count of a metre scale.

For example when we measure a substance which has a length of 1 inch (2.54 cm), we get a reading of either 2.5 cm or 2.6 cm. This measurement is not accurate.

Now, it is possible to measure such a reading with the help of a secondary scale called Vernier Scale, designed by a French scientist, Pierre Vernier. With the help of a Vernier Scale along with a metre scale, it is possible to measure length correct to 0.1 mm or 0.01 cm.

Least count

The smallest measurement that can be measured using a device or instrument is called least count of that instrument.

ACTIVITY –14.1

Find the least count of the different ammeters and voltmeters used in your school physics laboratory.

Least Count of a Vernier

Least Count (LC) of a Vernier is equal to the difference between a main scale division (MSD) and a Vernier scale division (VSD).

$$L.C = 1\ MSD - 1\ VSD$$

14.2.1. VERNIER CALIPERS (SLIDE CALIPERS)

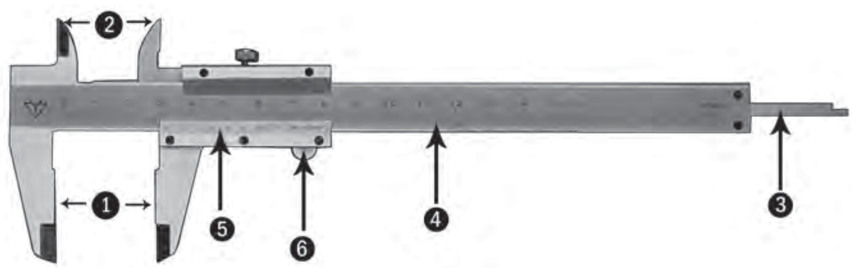
This instrument is based on the principle of Vernier.

The name Vernier is now applied to the small movable scale attached to a Caliper, Sextant, Barometer or other graduated instruments.

- The Vernier Calipers consists of a thin long steel bar graduated in cm and mm. This is called the Main scale.
- At the left end, an upper jaw and a lower jaw are fixed perpendicular to the bar called fixed jaws.
- To the right of the fixed jaws of the vernier calipers is found, the vernier scale consisting of an upper and a lower movable jaws that slides over the main scale.
- The Vernier scale can be moved or fixed at any position by using screws provided on it.

- The lower jaws are used to measure the external dimensions and the upper jaws are used to measure the internal dimensions of objects.
- The thin bar attached to the Vernier scale at the right side is used to measure the depth of hollow objects.

Vernier calipers



Parts

1. Lower Jaws
2. Upper Jaws
3. Depth Probe
4. Main Scale
5. Vernier
6. Retainer

ACTIVITY –14.2

Assume that your nail grows 2 mm per month. Calculate the growth per day, per hour and per minute.

Least count of a vernier calipers

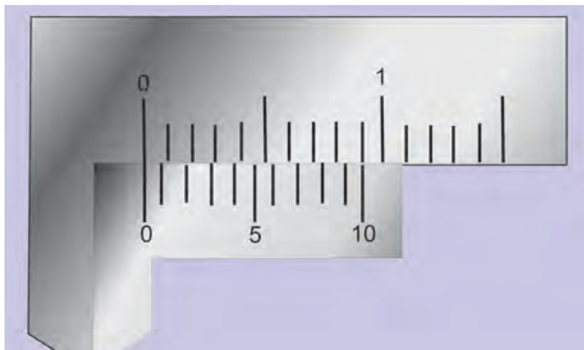
Consider 1 cm of a main scale. It is divided into 10 equal parts of length 1 mm. the Vernier scale has 10 equal divisions (VSD) equal to 9 Main scale divisions (MSD).

10 VSD	=	9 MSD
1 VSD	=	9/10 MSD
1 MSD	=	1 mm
1 VSD	=	9/10 mm
L.C	=	1 MSD – 1 VSD
	=	1 mm – 9/10 mm
	=	1/10 mm
L.C	=	0.1 mm = 0.01 cm

Error

Error may be defined as the deviation from the actual value. If the value is greater than that of actual value, it is called positive error. If the value is less than that of actual value, it is called negative error.

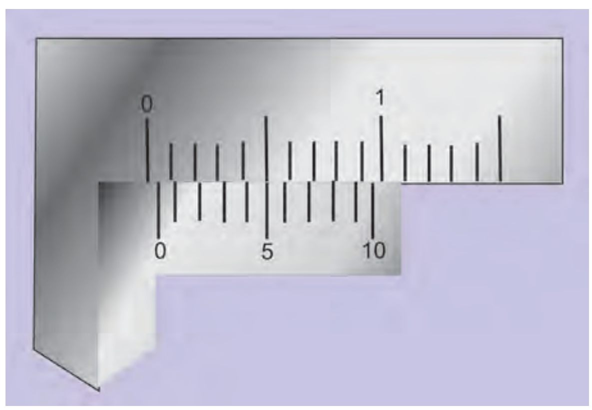
Zero Error of a vernier calipers



No Zero Error

Bring the two lower jaws into contact. If the zero of the Vernier scale coincides with the zero of the Main scale there is no zero error.

Positive Error

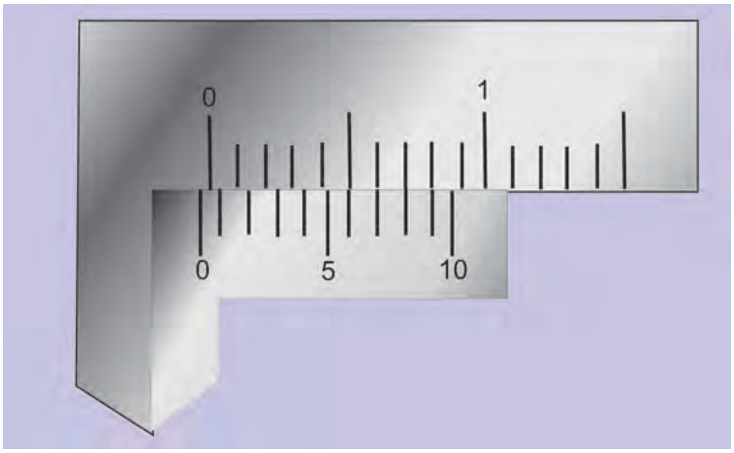


Positive Zero Error

If the zero of the Vernier scale is to the right of the Main scale zero, the zero error is positive and the zero correction (ZC) is negative.

For example, if the n^{th} division of the Vernier scale coincides with any division of the Main scale the Zero Error = + (n x L.C)

Negative Error



Negative Zero Error

If the zero of the Vernier scale is to the left of the Main scale zero, the zero error is negative and the zero correction (ZC) is positive. For example, if the n^{th} division of the Vernier scale coincides with a division of the Main scale the

Zero Error = – (10 – n) x L.C

Measuring the length of a cylinder

First find least count and zero error of a vernier calipers.

Now grip the cylinder whose length is to be measured between the two lower jaws.

Note the Main scale reading (MSR) just before the zero of the Vernier.

Note the division of the Vernier Scale which coincides (VC) with a Main Scale reading.

The observed length of the cylinder = MSR + (VC x LC)

The correct length of the cylinder = MSR + (VC x LC) ± ZC

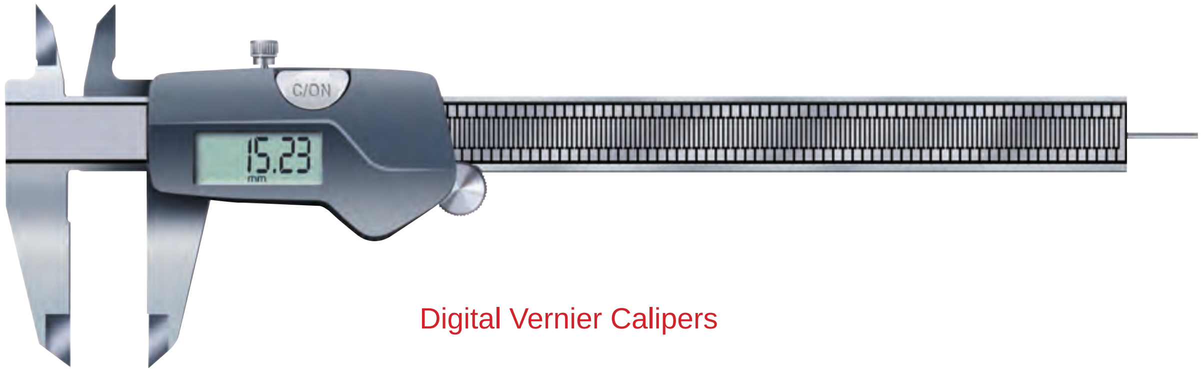
Take readings at different points on the cylinder.

Take the mean of the last column reading as the correct length of the object.

L.C. = ____________ Z.E. = ____________ Z.C. = ____________

S.No	Main Scale Reading (MSR) cm	Vernier Coincidence (VC)	Observed Reading (OR) = MSR+(VC x LC) cm	Corrected Reading OR ± ZC cm
1 2 3				

Digital Vernier calipers that are used nowadays give visual readings at once, that is they show the measurements as numerical display.



Digital Vernier Calipers

ACTIVITY –14.3

Find the volume of your geometry box / lunch box using Vernier calipers.

14.3. MEASURING MASS AND WEIGHT

When we look at the composition of different elements on the wrapper of drugs, it is given in milligram. This small measurement is possible by electronic (digital) balance. We can see a digital balance of accuracy 0.001g in a Jewellery shop.

Mass

Mass of a body is the measure of the quantity of matter contained in the body. It does not vary from place to place. The SI unit of mass is kilogram. It is measured using different types balances, which are the following.

Common (beam) balance

A beam balance compares the sample mass with a standard reference mass using a horizontal beam.

Two pan balance

This type of balance is commonly used for measuring mass in shops.

Physical balance

It is used in laboratories, to measure mass of an object correct to a milligram.

Weight

Weight is a measure of gravitational force on a body. It varies from place to place. It is measured using spring balance.

Weight = Mass x acceleration due to gravity

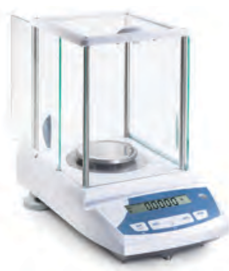
Spring balance

It measures weight by the distance a spring stretches under its load.

Medical scale

It is used to measure the body weight of human beings, it has a spring which compresses in proportion to the weight.

Digital balance



Now a days digital balance is used for accurate and quick measurement of weight. It works on strain gauge (length sensitive electrical resistance) scale principle.

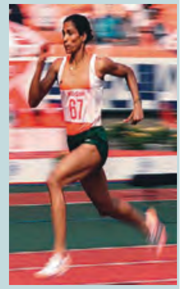
Weigh bridge

It is used to measure weight of very heavy objects such as lorries and trucks using principle of strain gauge.

Hydraulic scale

It is used to measure very heavy loads lifted by cranes which makes use of hydraulic force, to measure weight.

14.4. MEASURING TIME

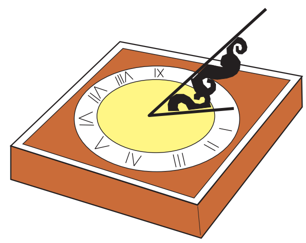


1984 Olympics was disastrous for P.T.Usha as she lost the bronze medal in 400m hurdles by 0.01s (1/100 s). How is the small time like 0.01s measured? Recently digital clocks, atomic clocks and quartz clocks allow the measurement of small times accurately.

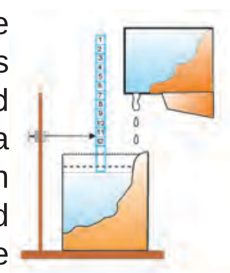
In ancient times, time was measured by sun dials, water clocks, sand clocks and graduated candles. During the night the position of stars (celestial bodies) in the sky was used to find time. All these methods were inaccurate.

Sun dial

It is based on the principle of the shadow of an object being formed on the ground when the sun rises and the sun sets.

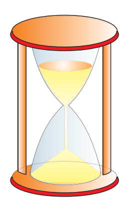


Water clock



These clocks are based on containers which are slowly filled with water coming out at a steady time. Markings on the inside surface is used to measure the passage of time.

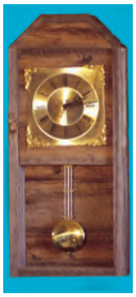
Sand clock



These clocks work similar to water clocks. Sand is used instead of water.

Mechanical clock

Galileo's discovery of the pendulum led to the invention of pendulum clock. Watches and small clocks were invented with hair spring (a spiral spring), in which balance wheel is used to keep accurate time.



Quartz clock

Quartz crystal watches offer better performance and accuracy. Quartz crystals vibrate with high frequency. These vibrations are used to indicate time in a liquid crystal display (LCD) digitally.

Atomic clock

The most accurate clocks used now a days are atomic clocks. It is based on the principle of periodic vibration taking place within the ceasium atom.

MORE TO KNOW

In India the time standard is provided by atomic clock kept at National Physical laboratory, New Delhi.

Local time and Standard time

The local time differs from place to place as it is calculated by the position of the sun. When the sun reaches the highest position in the sky over a place, the time is taken as 12 noon at that place. This is called local time.

Each country selects a standard meridian to set a uniform time irrespective of distances. The standard meridian of India is 82.5^0 E to calculate standard time. This time is called Indian Standard Time (IST)

The standard meridian of England is Greenwich Meridian is called Greenwich Mean Time (GMT). IST is 5½ hour ahead of GMT. i.e. 12 noon in England will be 5.30 pm in India.

An imaginary line drawn between north and south poles of the globe is called meridian. The earth is divided in to 24 time zones spacing 15^0 of longitudes, one for each hour of the day.

The meridian passing through the Royal observatory in Greenwich, England is taken as prime meridian with the origin of 0^0. When it is 7.00 am in New York city, it is 12.00 noon in London, UK and already 9.00 pm in Tokyo, Japan.

Symbols of measurement factors

Smaller Quantities

Factor	Prefix	Symbol
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	µ
10^{-9}	nano	n

Larger Quantities

Factor	Prefix	Symbol
10^{1}	deca	da
10^{2}	hecto	h
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G

ACTIVITY –14.4

Find your friends weight and time taken for 100 m race and fill it in the following table.

S.No.	Name	weight (kg)	time (s)

EVALUATION

Section A

1. 5 x 10^{7} µs is equivalent to

   a) 0.5 s   b) 5 s   c) 50 s   d) 500 s

2. While using Vernier calipers, to measure the internal diameter of a cylindrical pipe, pick out from the parts of the Vernier caliper given below.

   Depth probe, retainer, lower jaws, upper jaws

Section B

3. Match the following.

S.No.	Device	Place of use
1.	Beam balance	Jewellery shop
2.	Medical scale	Laboratories
3.	Physical balance	Hospitals
4.	Digital balance	Markets

4. In a vernier calipers, the difference between I MSD and 1VSD is found to be 0.1 mm. What does it represent?

5. Kavitha wants to find the thickness of a paper of her science textbook which contains 250 papers using vernier calipers. Explain how she might do this appropriately.

6. Calculate the correct readings of the vernier calipers from the given table.

Least count =0.01 cm Zero correction = Nil

S.No.	MSR	VC	Observed Reading = MSR + (VC x LC) cm	Correct Reading OR ± ZC cm
1.	3	4		
2.	3	7		

7. Complete the table choosing the right term from the list given in brackets.

(10^9 , micro, d, 10^{-9}, milli, m, M)

Factor	Prefix	Symbol
10^{-1}	deci	
10^{-6}		μ
	giga	G
10^{6}	mega	

8. A student measures the diameter of a bead using a digital vernier calipers. The reading in the vernier caliper is 4.27 cm. If he wants to verify the result with the ordinary vernier calipers with no error,

i) Where would be the zero of the vernier lie in the main scale?

ii) Which divisions of the vernier scale reading coincides with main scale reading.

Section C

9. i) Define least count of an instrument.

ii) Explain types of Zero error of vernier calipers.

iii) Write the steps involved in measuring any dimension of a given object using vernier calipers.

FURTHER REFERENCE

Books

1. Fundamentals of Physics - David Halliday & Robert Resnick JohnWiley
2. Complete Physics for IGCSE – Oxford publications

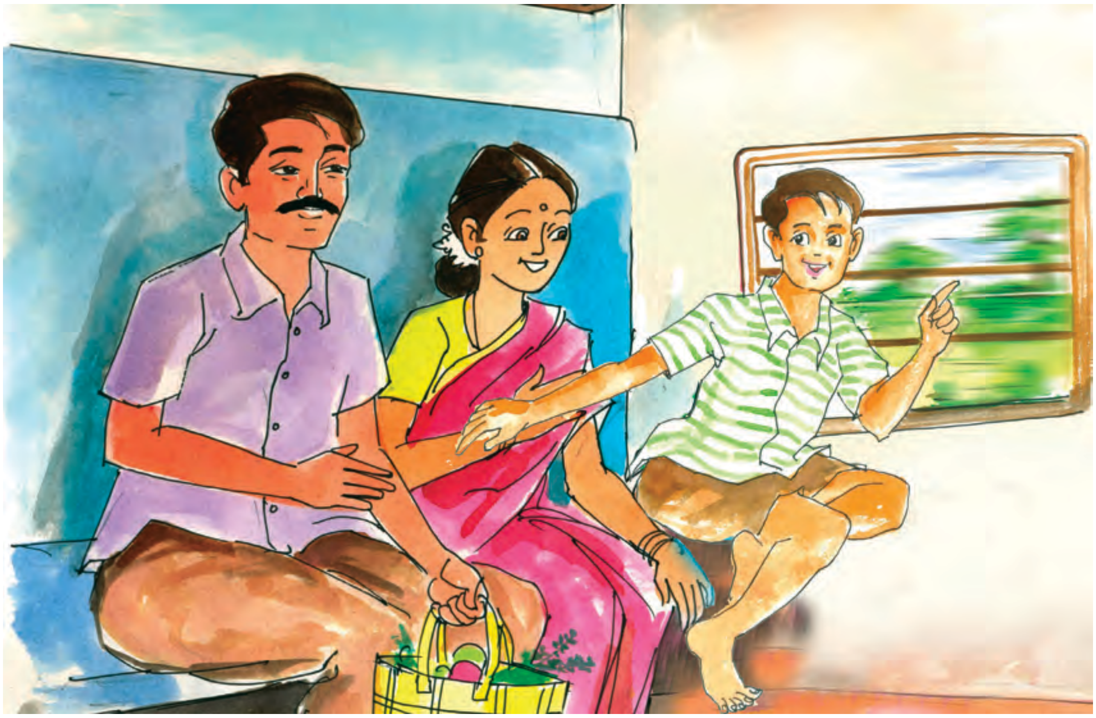
Websites

http://www.nist.gov/pml/
http://www.teach-nology.com
http://www.splung.com
http://www.khanacademy.org

Chapter 15

MOTION AND LIQUIDS

MOTION



Karthik and his parent were going to their native place by train to celebrate pongal festival. Karthik was watching the scenary through the window. He was surprised to see that the trees were seen to be receding. He asked his mother whether the trees really moved backwards. Mother explained that the trees were at rest. The trees seem to be receding because the train is in motion. Let us explain to Karthik and others about rest and motion.

15. MOTION

In the figure, the position of trees around the building is not changing with respect to the building. Then the trees are at rest.

When you are cycling or running, you are changing position with respect to trees and buildings. You are said to be moving.

Inference

A body is said to be in the state of rest when it remains in the same position with respect to time. A body is said to be in the state of motion, when it continuously changes its position with respect to time.

ACTIVITY –15.1

List out certain things which are at rest or in motion related to you.

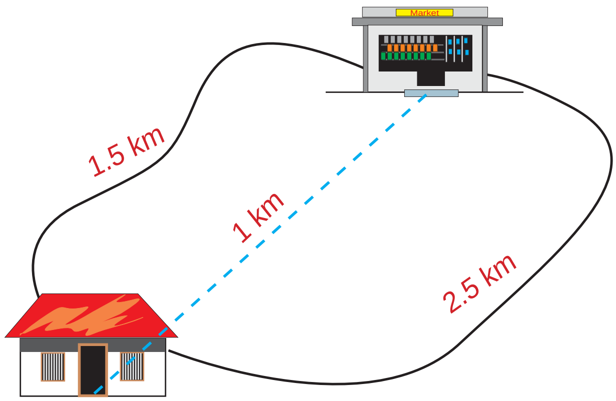
S. No.	Rest	Motion
01	House	Sun
02		
03		
04		
05		

ACTIVITY –15.2

Discuss which of the objects in the class room are at rest and which are in motion.

Measuring the rate of motion

A farmer takes vegetable from his house to the market everyday. He may travel along two paths to reach the market.



Answer the following questions by observing the figure.

1. What is distance? How much distance does the farmer travel everyday? Distance is the length of the path covered. The farmer travels a distance of 1.5km, when he takes path1 and 2.5 km when he travels along path 2.

Inference

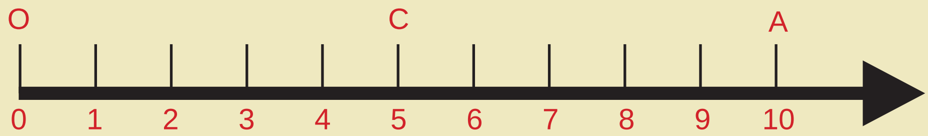
The distance between the two places is not the same; it depends upon the path chosen.

2. What will be the shortest distance between the house and the market? It is the distance covered when travelled along a straight line. It is 1 km. This is known as displacement.

Inference

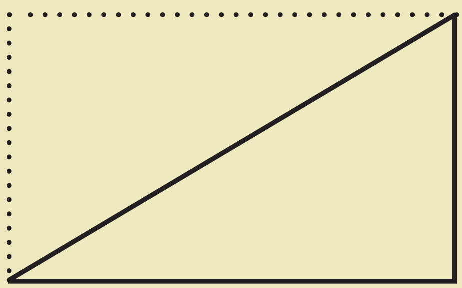
The shortest distance, or distance travelled along a straight line, is known as displacement.

ACTIVITY –15.3



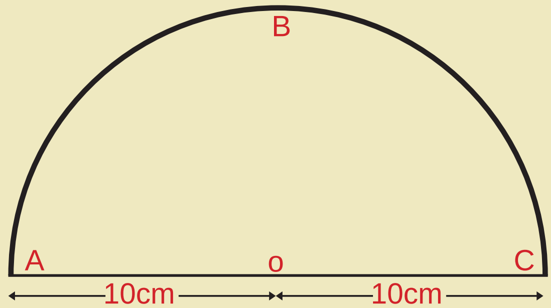
Consider the motion of an ant along a straight line path. The ant starts its journey from 'O'. Let 'A' and 'C' represent the position of the ant at different instances. At first, the ant moves through C and reaches A. Then it moves back along the same path and reaches C. Find the distance travelled by the ant and displacement.

ACTIVITY –15.4



Walk from one corner of your classroom to the opposite corner along the sides. Measure the distance covered by you. Now walk diagonally across to the opposite corner, and measure the displacement. Note the difference.

ACTIVITY –15.5



Draw a semicircle of radius 10cm. Measure the path ABC(distance) and AOC(displacement). You can observe that distance = 31.4cm and displacement = 20cm.

15.1. UNIFORM MOTION AND NON UNIFORM MOTION

Consider the race between the hare and the tortoise. The data regarding the motion of the two are given in the table.

Time (minute)	Distance travelled by hare(m)	Distance travelled by tortoise(m)
5	10	5
10	30	10
15	35	15
20	35	20
25	35	25
30	35	30
35	35	35
40	35	40
45	35	45
50	48	50

From the data, we notice that the tortoise covers 5m in every 5 minute. It covers the same distance in a particular time throughout its motion. This type of motion is known as uniform motion.

If an object covers equal distances in equal intervals of time, it is said to be in uniform motion.

The hare, in its motion, covers different distances in a particular time. This type of motion is known as non-uniform motion.

If an object covers unequal distance in equal intervals of time, it is said to be in non-uniform motion.

15.2. MEASURING THE RATE OF MOTION

Speed

A car starts from Salem and reaches Chennai in 6 hour. A bus takes 8 hour to travel the same distance.

Which has moved faster? Why?

The car travels faster than the bus, because it covers the distance in a short time.

Inference

When a body covers a distance in a short time, it is said to be fast. If it takes more time to cover the distance, it is said to be slow.

Speed is the quantity used to say whether the motion is slow or fast. Speed is the distance travelled in one second (or) rate of distance travelled.

$$\text{Speed} = \frac{\text{Total Distance travelled}}{\text{Time taken}}$$

Speed is measured in m/s (or) ms^{-1}

It can also be expressed in km/hour (or) kmh^{-1}

Example

A train moves with a speed of 100 km/hour, means it will cover a distance of 100km in 1 hour.

ACTIVITY –15.6

List some examples of uniform and non uniform motion.

Uniform	Non-uniform
Oscillation of pendulum of a wall clock.	Movement of a car in a crowded street.

Try this:

A car takes 6 hours to cover a distance of 300 km. What is its speed?

If the same car travels with a speed of 60km/hour, how much time it will take to travell the same distance?

If it has to cover the distance in 5 hour, what will be the speed?

Velocity

When we speak of speed, the direction of motion is not considered. If we take into account the direction of motion also, then we can understand the motion clearly. (The speed with direction is known as velocity).

To measure the velocity, we should consider displacement instead of distance.

Velocity is the displacement made in one second (or) rate of change of displacement.

Rate of change means, change per second.

$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$$

It is also expressed in m/s

Uniform Velocity

Equal displacement covered by a body in equal intervals of time is known as uniform velocity.

15.3. RATE OF CHANGE OF VELOCITY

During uniform motion of an object along a straight line, the change in the velocity of the object for any time interval is zero. However, in non-uniform motion, velocity varies with time. How can we now express the change in velocity of an object?

For this, we have to introduce another physical quantity called acceleration.

Acceleration is the change in velocity of an object per second or rate of change of velocity.

$$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{Time taken}}$$

The unit of acceleration is m/s^2 or ms^{-2}

If the velocity of the body increases with time, the acceleration is positive, and the kind of motion is called accelerated motion. If the velocity of the body decreases with time, the acceleration is negative (retardation), and the motion is called decelerated motion.

Example : Train comes to rest at the station.

Uniform Acceleration

If an object travels in a straight line and its velocity increases or decreases by equal amount in equal intervals of time, then the acceleration of the object is uniform.

Example

A car moves with a uniform acceleration of 8 m/s^2, means its velocity increases by 8 m/s for every second.

A train moves with a uniform acceleration of -10 m/s^2 or retardation of 10 m/s^2, means its velocity will decrease by 10 m/s for every second.

The velocity of a car changes from 10 m/s to 50 m/s in 10 second. What will be its acceleration?

$$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{Time taken}}$$

$$a = \frac{\text{(final velocity - initial velocity)}}{\text{Time}}$$

$$a = \frac{(50 - 10)}{10}$$

$$a = \frac{40}{10}$$

$$a = 4\ m/s^2$$

From the above example, we can give a formula for acceleration.

$$a = \frac{v - u}{t}$$

where,

u - initial velocity

v - final velocity

t - time

MORE TO KNOW

S.No.	Motion	Speed	
		ms^{-1}	Kmh^{-1}
1	Rat	0.5	1.8
2	Man	1.0	3.6
3	Bee	5.0	18
4	P.T.Usha	9	32.4
5	Cheetah	24	86.4
6	Speed of sound	340	1224
7	Speed of light	$3x10^8$	$10.8x10^8$

ACTIVITY –15.7

From the following motion of different buses, find whether the acceleration is (a) uniform positive (b) non uniform positive (c) zero (d) uniform negative and (e) non uniform negative.

Time (s)	Speed (km h^{-1})				
	Bus A	Bus B	Bus C	Bus D	Bus E
2	10	10	0	3	20
4	10	8	4	6	18
6	10	6	6	9	14
8	10	4	9	12	8
10	10	2	12	15	3
12	10	0	14	18	0

15.4 GRAPHICAL REPRESENTATION OF MOTION

Distance - time graph

We can easily understand the relation between time and distance by using a graph.

Taking a suitable scale, a graph is drawn by taking time along the x axis and distance along the y axis. The graph is known as distance – time graph.

Uniform motion

The following table shows the distance walked by Murugan at different times.

Time (minute)	Distance (metre)
0	0
5	500
10	1000
15	1500
20	2000
25	2500

ACTIVITY –15.8

The time of arrival of a lorry at Madurai, Thirunelveli and Nagarcoil from Trichy and the corresponding distance from Trichy are given in the following table.

station	distance (km)	time of arrival
Trichy	0	5.00 am
Madurai	120	8.00 am
Thirunelveli	270	11.45 am
Nagarcoil	350	1.45 pm

Plot the distance-time graph for the lorry and find the speed of the lorry from the graph.

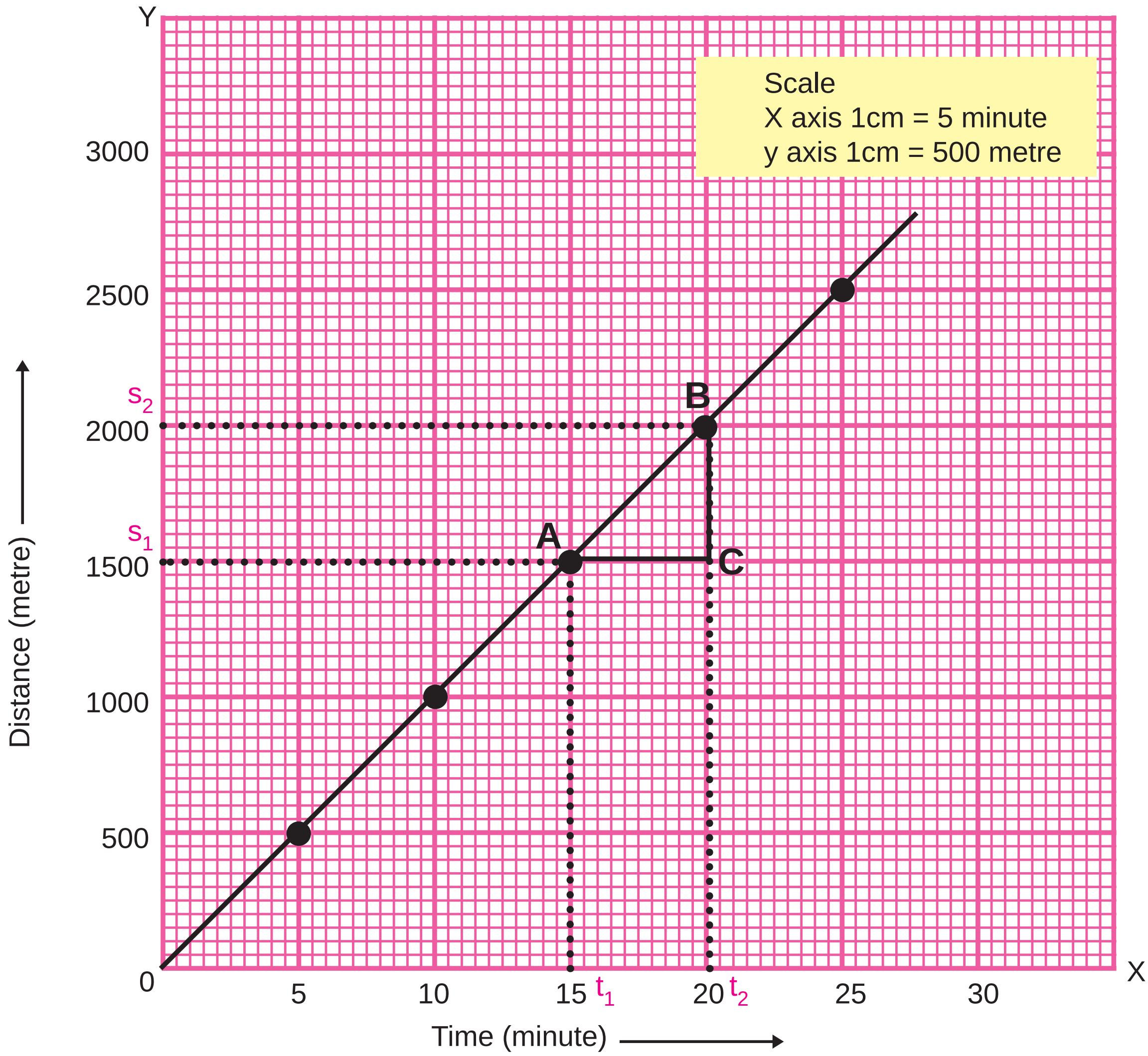


Fig 15.1

Here, Murugan covers equal distance in equal intervals of time. He walks with uniform speed. The graph is a straight line for uniform speed.

The speed of Murugan can be found from the distance-time graph as shown in Fig 15.1. Consider a small part AB. From B draw a perpendicular to x axis. From A, draw a line parallel to x axis. These two lines meet each other at C to form a triangle ABC. Now on the graph, BC corresponds to the distance $(s_2\text{-}s_1)$ and AC denotes the time interval $(t_2\text{-}t_1)$. Speed of the object,

$$v = \frac{(S_2 - S_1)}{(t_2 - t_1)} = \frac{BC}{AC}$$

Accelerated motion (Non uniform velocity)

The following table shows the distance travelled by a car in a time interval of 2 s.

Time s	0	2	4	6	8	10	12
Distance m	0	1	4	9	16	25	36

The distance - time graph, for the motion of the car, is shown in Fig 15.2.

The nature of the graph shows, non-linear variation of the distance travelled by the car. Thus the graph represents motion with non-uniform speed.

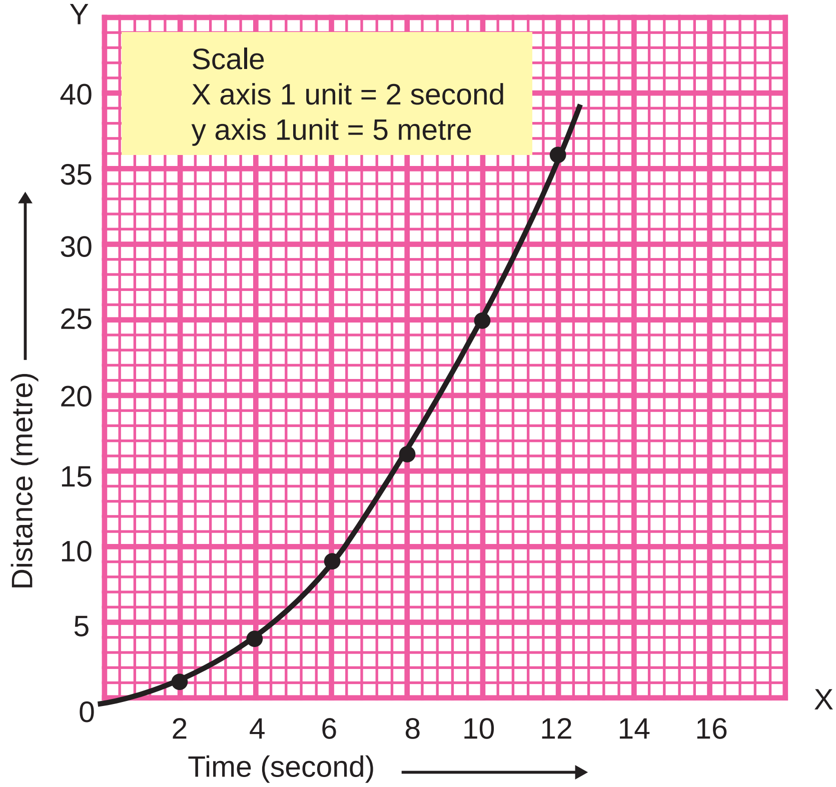


Fig 15.2.

Velocity-Time graph

The variation in velocity with time for an object moving in a straight line can be represented by a velocity-time graph.

Uniform velocity (Un-accelerated motion)

The following graph shows the velocity-time graph for a car moving with uniform velocity of 40kmh^{-1}.

In this graph, time is taken along the x axis and velocity is taken along the y axis.

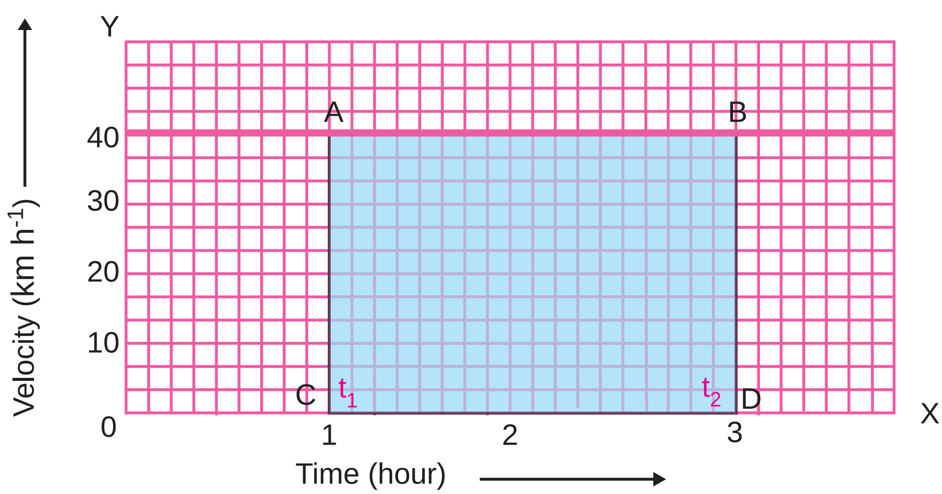


Fig 15.3.

In the graph (Fig 15.3), AC or BD represents the velocity and CD or AB represents time $t_2 - t_1 = 3 - 1 = 2$ hour.

We have,

Displacement = velocity x time

s = AC x CD or AB x BD

= 40 x 2

= 80 km

Uniformly accelerated motion

The following table shows the velocity of a car at regular intervals during a test drive.

Time (s)	Velocity (km h^{-1})
0	0
5	2.5
10	5.0
15	7.5
20	10.0
25	12.5

The velocity-time graph for the motion of the car is shown as in Fig 15.4.

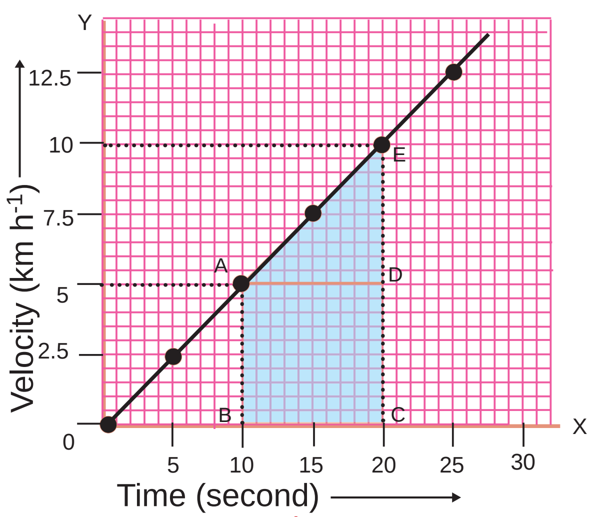


Fig 15.4.

The nature of the graph shows that velocity changes by equal amounts in equal intervals of time. The displacement 's' of the car will be given by area ABCDE under the velocity-time graph.

s = Area ABCDE

s = Area of the rectangle ABCD + area of the triangle ADE

$$s = AB \times BC + \frac{1}{2}(AD \times DE)$$

Non-uniformly accelerated motion

In the case of non-uniformly accelerated motion, velocity-time graph can have any shape.

The following velocity-time graph, as shown in Fig 15.5, represents the non-uniform variation of velocity of a car with time.

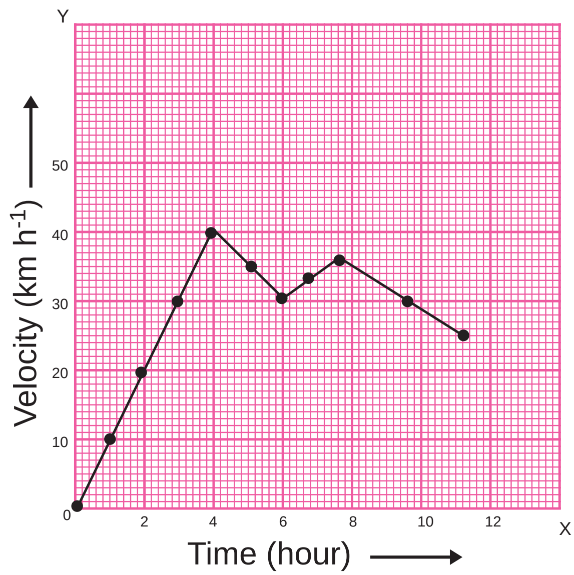


Fig 15.5.

ACTIVITY –15.9

Form two groups A & B consist of 5 students each. The two groups stand at two junctions of the road separated by a distance of 500 m. Let the two groups record the vehicle number, types of vehicle and time of crossing the junctions on either side for 15 minute. From the data, calculate the speed of different vehicles and the number of vehicles violated the speed limit.

ACTIVITY –15.10

Rahul and his sister Ramya go to school on their bicycles. Both of them start at the same time from their home, they take different time to reach school, although they follow the same route.

The following table shows the distance travelled by them in different times.

Time	Distance travelled by Rahul (km)	Distance travelled by Ramya (km)
8.00 am	0	0
8.05 am	1.0	1.0
8.10 am	2.0	1.9
8.15 am	3.0	2.7
8.20 am	4.0	3.5
8.25 am	--	4.0

Plot the distance-time graph for their motions on the same scale and explain.

15.5. EQUATIONS OF MOTION (GRAPHICAL METHOD)

Consider an object moving along a straight line with a uniform acceleration 'a'. The velocity of the object changes from u to v in a time t. s is the displacement of the object, in the time t.

The velocity-time graph of the object is shown in Fig 15.6.

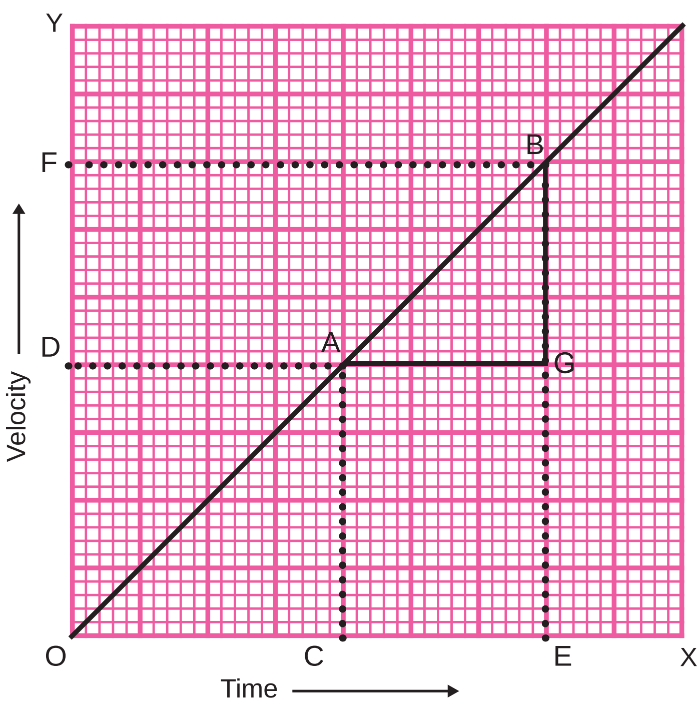


Fig 15.6.

A and B are two points taken on the graph. The velocity at A is the initial velocity u and that at B is the final velocity v.

From A, draw two perpendiculars, one to the x axis (AC) and another to the y axis (AD). Similarly, perpendicular lines are drawn from B (BE & BF)

AG is the perpendicular drawn from A to BE.

Equation for velocity at a time

In the graph, AC gives the initial velocity (u). BE gives the final velocity (v). CE represents the time taken t. DF gives the change in velocity.

$$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{Time}}$$

$$a = \frac{DF}{CE} = \frac{OF\text{-}OD}{OE\text{-}OC}$$

But OE - OC = t

$$a = \frac{v-u}{t}$$

$v - u = at$ …… (i)

$v = u+at$ ……(I)

Equation for displacement

Let 's' be the displacement of the body in a time t.

In the graph,

Displacement = Area CABE

s = Area of the rectangle CAGE + Area of the triangle ABG.

$s = AC \times CE + \frac{1}{2}(AG \times GB)$

Here AC = u

CE = t

AG = t

GB = v-u = at [from(i)]

$s = ut + \frac{1}{2} \times t \times at$

$s = ut + \frac{1}{2}at^2$ ……. (II)

Equation for velocity at a position

In the graph,

Displacement = Area of the trapezium CABE

$s = \frac{1}{2}(AC+EB) \times CE$

Here AC = u

EB = v, CE = t

$s = \frac{u+v}{2} \times t$ ………(ii)

From (i), $t = \frac{v-u}{a}$

Substituting the value of t,

$s = \frac{u+v}{2} \times \frac{v-u}{a}$

$s = \frac{v^2 - u^2}{2a}$

$v^2 - u^2 = 2as$

$v^2 = u^2 + 2as$ …………….(III)

(I), (II) and (III) are the equations of motion.

Acceleration due to gravity

What do we observe when a body is thrown vertically upwards?

The velocity of the body gradually decreases and becomes zero at a maximum height.The body is decelarated or retarded.

When the body is allowed to fall down, the velocity gradually increases. Now the body is accelerated.

The decelaration or acceleration due to the gravitational force of earth is known as accelaration due to gravity, denoted as 'g'.

The average value of 'g' is $9.8\ m/s^2$. The velocity of the body thrown vertically upwards will decrease by 9.8m for every second and the velocity of a body falling down increases by 9.8m for every second.

The equations of motion for this body can be obtained from the equations of motion.

$v = u + at$

$s = ut + \frac{1}{2}at^2$

$v^2 = u^2 + 2as$

For the body thrown upwards, equations can be obtained by substituting a = -g and s = h

we get, $v = u - gt$

$h = ut - \frac{1}{2}gt^2$

$v^2 = u^2 - 2gh$

When a body allowed to fall freely, u = 0. a = g and s = h

Now, the equations will be

$v = gt$

$h = \frac{1}{2}gt^2$

$v^2 = 2gh$

15.6. UNIFORM CIRCULAR MOTION

An athlete runs along the circumference of a circular path. This type of motion is known as circular motion.

The movement of an object in a circular path is called circular motion. When an object moves in a circular path with a constant speed, its motion is called uniform circular motion.

In uniform circular motion, the magnitude of the velocity is constant at all points and the direction of the velocity changes continuously.

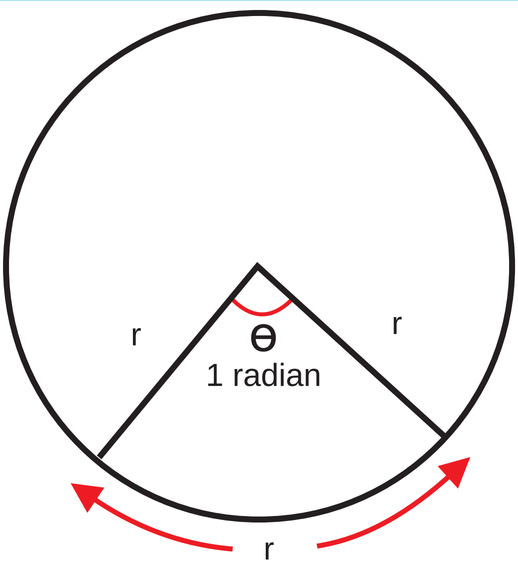
How is the velocity of the body moving along a given circular path?

Already we have given the velocity by using displacement. This is termed as linear velocity. Now we can give the velocity in another way by considering the angle covered by the body. This is known as angular velocity.

In what unit, do we measure angle?

Angle is measured in degree. But we can have another unit called radian.

One radian is the angle subtended by an arc of a circle of length equal to its radius at the centre of the circle.



Angular displacement

The angle covered by the line joining the body and the centre of the circle (radius vector). It is measured in radian.

Angular velocity

The angular displacement in one second (rate of change of angular displacement) is called angular velocity.

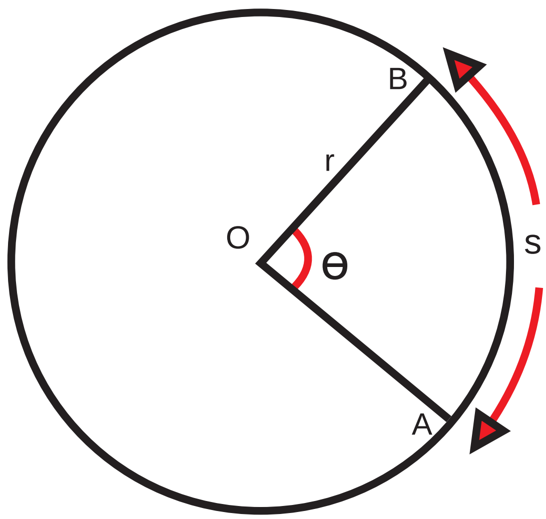
$$\text{Angular velocity} = \frac{\text{angular displacement}}{\text{time taken}}$$

$$\omega = \frac{\theta}{t}$$

Can you give the unit of angular velocity?

It is radian / second.

Relation between linear velocity and angular velocity



Consider a body moving along the circumference of a circle of radius r with linear velocity v. Its angular velocity is ω. Let the body moves from A to B in a time t and ϴ is the angle covered.

Let AB = S = displacement

Linear velocity = displacement / time

$$v = \frac{AB}{t}$$

$$v = \frac{S}{t} \quad \ldots\ldots\ldots\ldots(1)$$

If ɵ is the angle subtended by an arc of length s and radius r. Then

$$S = r\,\theta \quad \ldots\ldots\ldots\ldots(2)$$

Substituting (2) in (1),

$$v = \frac{r\,\theta}{t}$$

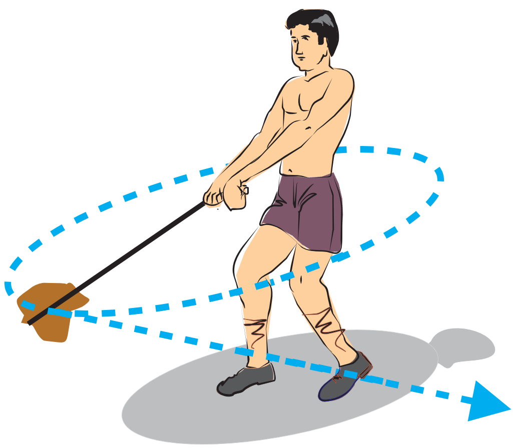
But $\frac{\theta}{t} = \omega$ = angular velocity

$$v = r\,\omega$$

Linear velocity = Radius of the circle x Angular velocity

15.6.1. CENTRIPETAL FORCE AND CENTRIFUGAL FORCE

Take a piece of thread and tie a stone at one of its ends. Move the stone to describe a circular path with constant speed by holding the thread at the other end as shown in the figure.



Now let the stone go by releasing the thread. Repeat the activity for few times and release the stone at different positions. Check the direction of motion of the stone.

We notice that the stone moves along a straight line tangential to the circular path. This is because once the stone is released, it continues to move along the direction it has been moving at that instant. This shows that the direction of motion changed at every point when the stone was moving along the circular path.

This shows that there is a force acting along the string directed inwards, makes the body move in the circular path. This force is known as centripetal force.

The constant force that acts on the body along the radius towards the centre and perpendicular to the velocity of the body is known as centripetal force.

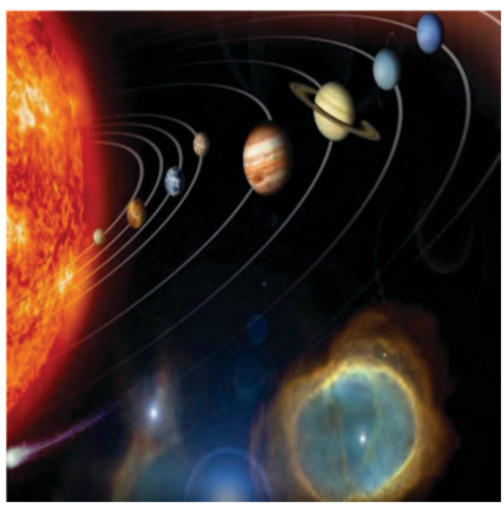
Let us consider an object of mass m, moving along a circular path of radius r, with an angular velocity ω and linear velocity v.

$$F = \frac{mv^2}{r}$$

Again, centripetal force, $F = mr\omega^2$
(since $v = r\omega$)

Examples

1. In the case of the stone tied to the end of a string and rotated in a circular path, the centripetal force is provided by the tension in the string.
2. When a car takes a turn on the road, the frictional force between the tyres and the road provides the centripetal force.
3. In the case of planets revolving round the sun or the moon revolves around the earth, the centripetal force is provided by the gravitational force of attraction between them.



4. For an electron revolving around the nucleus in a circular path, the electro static force of attraction between the electron and the nucleus provides the necessary centripetal force.

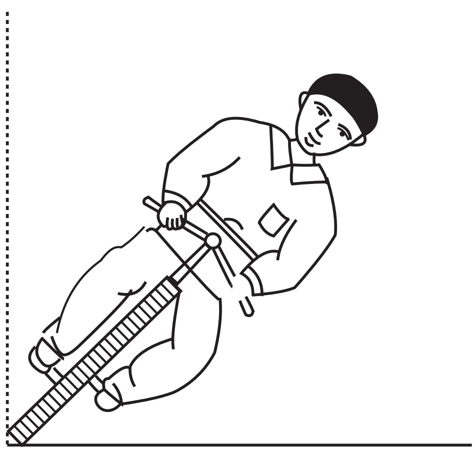
In the first example (stone), not only is the stone acted upon by a force (centripetal force) along the string towards the centre, but the stone also exerts an equal and opposite force on the hand away from the centre along the string.

The force, which is equal in magnitude but opposite in direction to the centripetal force is known as centrifugal force.

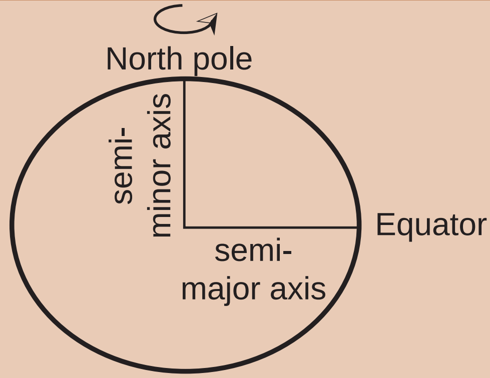
Examples

1. While churning curd, butter goes to the side due to centrifugal force.

2. A cyclist turning a corner leans inwards. Now the frictional force (centripetal force) is balanced by the centrifugal force $\frac{mv^2}{r}$



MORE TO KNOW



The earth is flattened at the poles and bulged at the equator. The diameter of the earth is 48 km more at the equator than at the poles. The velocity of the particles at the equator is more than the velocity of the particles at the poles. So centrifugal force acting on the particles is more at the equator. This is the reason for the bulging of the earth at the equator.

15.7. LIQUIDS

Liquids flow from one place to another. They have a definite volume. They take the shape of the container. Liquids show very little change in volume even when large compressive forces are applied. So we assume that liquids are incompressible.

15.7.1.UPTHRUST AND BUOYANCY

ACTIVITY –15.11

Take a piece of cork, press it inside water in a beaker. What do you feel? press it to more depth. What difference do you notice at various depths?

You will find it more difficult to push it as it goes deeper. This indicates that water exerts force on the cork in the uphold direction. The upward force exerted by water goes on increasing as the cork is pressed deeper.

We know that, pressure at any point inside a liquid is p = hdg. This shows that pressure increases with depth.

When a body floats or immerses in a liquid, the pressure on the bottom surface is more than that the pressure on the top surface. Due to the difference in pressure, an upward force acts on the body. This upward force is called upthrust or buoyant force. The buoyant force is equal to the weight of the liquid displaced.

The buoyant force (upthrust) acts through the centre of gravity of the displaced liquid which is known as centre of buoyancy.

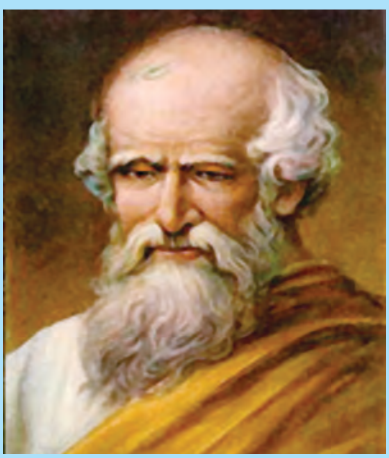
Due to the upthrust exerted on the body by the liquid, the weight of the body appears to be less when the body is immersed in the liquid.

For example, when we immerse a mug into a bucket of water, the mug filled with water appears to be lighter as long as it is under water. But when it is lifted up out of the water we feel that the mug is heavier. This shows that the weight of the body under water is less than its weight when it is above the surface of water.

15.7.2. ARCHIMEDES

Archimedes

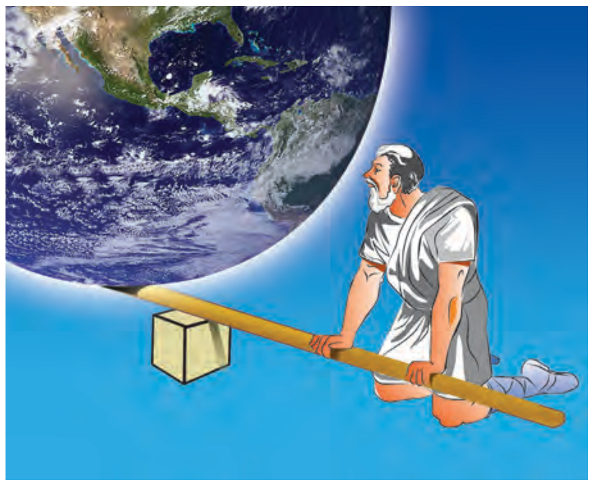
Archimedes was a Greek scientist (287 – 212 BC)



Archimedes discovered many important principles of statics and hydrostatics and put them into practice. He was the son of an astronomer and a friend and relative of Hiero, king of Syracuse. He received his training and education in Alexandria, which was the centre of learning in those days.

Lever

He invented the water screw for irrigating the fields of Egypt. He discovered the principle of lever and is reported to have said to the king : "Give me a place where I may stand and I will move the world". He invented many mechanical devices to drop heavy weights on Roman ships which attacked the Greeks.



Eureka

The famous principle in hydrostatics, known as Archimedes principle is said to have been proposed under very peculiar circumstances. The king had ordered a jeweller to make for him a crown of gold as an offering to God. When the crown was delivered, the king suspected it, be adulterated with silver and so he asked Archimedes to investigate. When Archimedes kept pondering over the matter; one day, during his bath, he observed that his limbs were buoyed up. It at once struck him that all bodies immersed in water would lose weight in this way. This excited him so much that forgetting to dress himself up, he ran out of his bath shouting "EUREKA" which means, "I have found it".

ACTIVITY –15.12

Perform a skit in the school on the life history of Archimedes.

Archimedes Principle

When a body is immersed in fluid (liquid or gas) it experiences an apparent loss of weight which is equal to the weight of the fluid displaced.

Experiment to verify Archimedes principle

Suspend a piece of stone from the hook of a spring balance.

Note the weight of the stone in air (w_1)

Gently lower the stone in to the water of an overflowing jar filled to its maximum capacity with water as shown in figure.

Now note the weight of the stone (w_2)

Find the weight of a beaker (w_3)

Collect the overflowing water in the beaker.

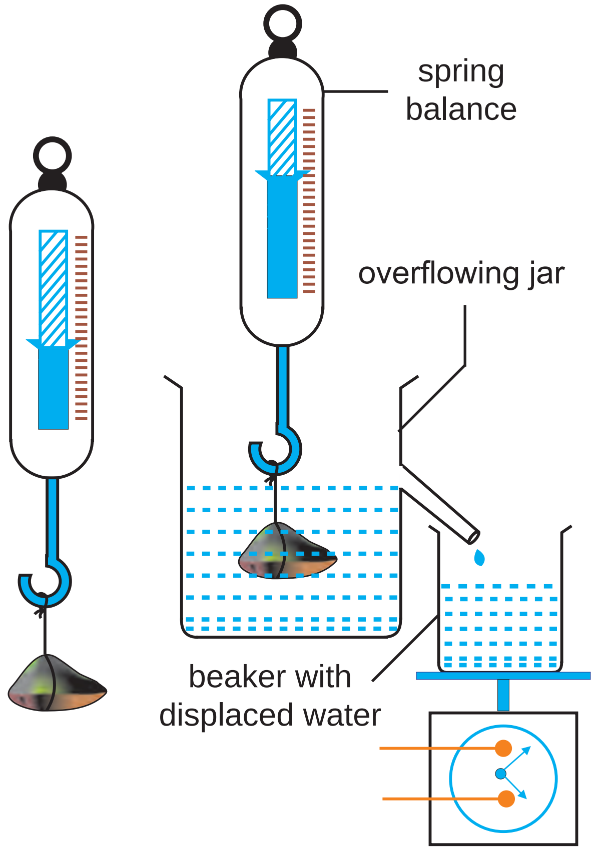
Weigh the beaker with water (w_4)

Find the weight of the displaced water ($w_4 - w_3$)

Find the loss of weight of the stone ($w_1 - w_2$)

We find that $(w_1 - w_2) = (w_4 - w_3)$.

Thus Archimedes Principle is verified.



15.7.3. RELATIVE DENSITY

Density

Density of a body is defined as the mass per unit volume of the body.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

Unit of density is Kg m^{-3}

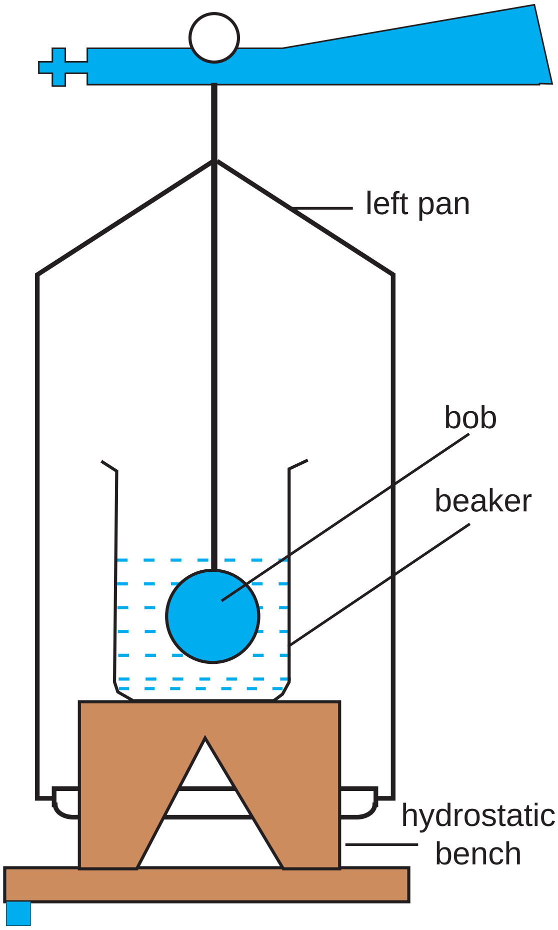
Relative density

Relative density is defined as the ratio of density of the body to the density of water.

It has no unit.

Determination of Relative density

1. To determine the relative density of a insoluble solid heavier than water using Archimedes principle.



Suspend the given body from the hook of the left scale pan of the physical balance.

Find the mass in air. (m_1)

Immerse the body in a beaker of water placed on a hydrostatic bench.

Find the mass in water. (m_2)

Take care that there are no air bubbles sticking to the body, that the body is not touching the sides or bottom of the beaker and that the body is completely immersed inside water.

Calculation

Mass of the solid in air = m_1 g

Mass of the solid in water = m_2 g

Loss of mass in water = $(m_1 - m_2)$ g

Mass of displaced water = $(m_1 - m_2)$ g

Volume of water displaced = $(m_1 - m_2)$ cc

(since 1 gm of water has a volume of 1 cc)

Volume of the body = $(m_1 - m_2)$ cc

Density of the solid

$$= \frac{\text{Mass of the substance}}{\text{Volume of the substance}}$$

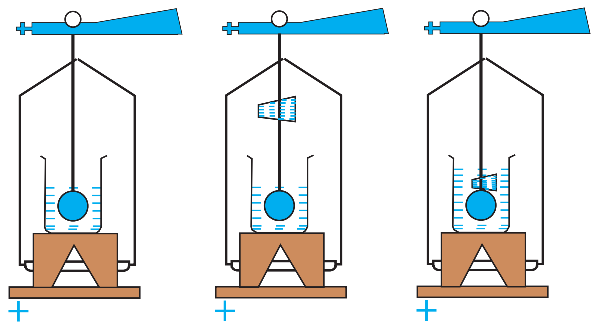
$$= \frac{m_1}{m_1 - m_2} \text{ g cm}^{-3}$$

$$\text{Relative density of the solid} = \frac{m_1}{m_1 - m_2}$$

no unit

(since the density of water = 1 g cm^{-3})

2. Relative density of a solid lighter than water (cork)



A brass bob can be used as a sinker in order to keep the cork in water.

Suspend the brass bob from the left scale pan.

Immerse it in a beaker of water placed on a hydrostatic bench.

Find the mass. (m_1)

Tie the cork to the same string in such a way that it is in air and the brass bob is in water.

Find the mass. (m_2)

Tie the cork together with the bob.

Immerse both of them in water.

Find the mass. (m_3)

Mass of the cork in air = $(m_2 - m_1)$ g

Mass of the cork in water = $(m_3 - m_1)$ g

Loss of mass of cork in water = $(m_2 - m_1)$ - $(m_3 - m_1)$ g = $(m_2 - m_3)$ g

Relative density of cork

$$= \frac{\text{Mass in air}}{\text{Loss of mass in water}}$$

$$= \frac{m_2 - m_1}{m_2 - m_3} \quad \text{(no unit)}$$

3. Relative density of a liquid

Take a brass bob which is insoluble either in water or in the given liquid.

Suspend the brass bob from the hook of the left scale pan.

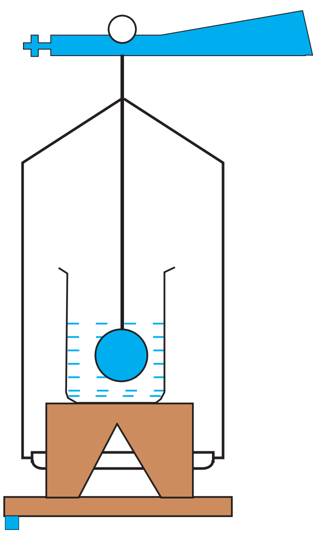
Find the mass. (m_1)

Immerse the bob in a beaker of water placed on a hydrostatic bench.

Find the mass. (m_2)

Now immerse the bob in the given liquid.

Find the mass. (m_3)



Calculations

Mass of the solid in air = m_1 g

Mass of the solid in water = m_2 g

Mass of the solid in liquid = m_3 g

Loss of mass in water = $(m_1 - m_2)$ g

Loss of mass in liquid = $(m_1 - m_3)$ g

Volumes of water displaced and liquid displaced are equal.

Relative density of the liquid

$$= \frac{\text{Loss of mass in liquid}}{\text{Loss of mass in water}}$$

$$= \frac{m_1 - m_3}{m_1 - m_2} \quad \text{(no unit)}$$

15.7.4 EXPLANATION FOR A BODY WHOLLY OR PARTIALLY IMMERSED IN A LIQUID

ACTIVITY –15.13

Take a beaker filled with water.

Take a piece of cork and an iron nail of equal mass.

Place them on the surface of water.

observe what happens?

The cork floats while the nail sinks. This is because of the difference in their densities. The density of cork is lesser than the density of water. This means that the upthrust of water on the cork is greater than the weight of the cork. So it floats.

The density of the iron nail is more than the density of the water. This means that the upthrust of water on the iron is lesser than the weight of the nail. So it sinks.

An iron piece floats in mercury, but sinks in water .This is because the density of mercury (13600 kg m^{-3}) is greater than the density of water (1000 kg m^{-3}). Even though the volumes of mercury and water displaced are equal to the volume of the iron piece, the weight of mercury displaced by the iron piece (upthurst) is greater than the weight of iron piece. But the weight of water displaced is lesser than the weight of iron piece.

A ship made up of iron floats in water. This is because the ship is hollow and contains air. The large space inside the ship enables it to displace a volume of water much greater than the actual volume of iron that was used in the construction. So the weight of water displaced is greater than the weight of the ship.

A body which floats in a liquid is in equilibrium under the action of the two forces. (a) It's weight acting vertically downwards and (b)the resultant thurst on it due to the liquid acting upwards. These two forces must be equal and opposite. The resultant upthurst may be equal to or greater than the weight of the liquid displaced by the body, and that it acts through the centre of gravity of the displaced liquid.

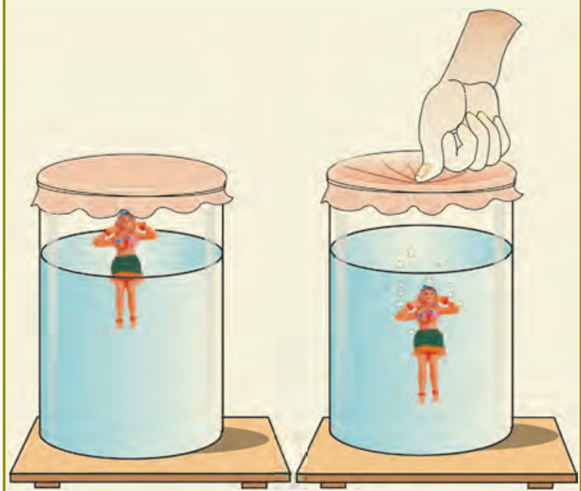
Laws of floatation

1. The weight of the floating body is equal to the weight of the liquid displaced by it .
2. The centre of gravity of the floating body and the centre of gravity of the liquid displaced (centre of buoyancy) are in the same vertical line.

MORE TO KNOW

The density of air is 14 times greater than that of hydrogen. The weight of a hydrogen filled balloon is much less than the weight of the air it displaces. The difference between the two weights gives the lifting power of the balloon. Thus a hydrogen filled balloon flies high in the air.

ACTIVITY –15.14



Take a small hollow plastic doll. Put a hole. Take a container with water. Cover the mouth of the container with a rubber sheet. Press the rubber sheet. Now the doll sinks in water.

When the rubber sheet is pressed, the pressure inside the container increases and it forces the water to enter into the doll through the hole. the weight of the doll is now more than the weight of the water displaced by it and the doll sinks.

Hydrometers

The laws of floatation are made use of in the construction of hydrometers used for the determination of the specific gravities of solids and liquids.

There are two types of hydrometers (1) The constant immersion hydrometer, in which the weight of the hydrometer is adjusted to make it sink to the same fixed mark in all liquids.

(2) The variable immersion hydrometer in which the weight of the hydrometer remains the same , but the depth to which it sinks in different liquids vary.

The common hydrometer

The common hydrometer is of variable immersion type. It is graduated such that the specific gravity of a liquid can be directly determined. It consists of a narrow uniform stem of glass, closed at the top and provided with a glass bulb at the bottom. The bulb is weighed with mercury or leadshots to make the hydrometer to float vertically in various liquids as shown in Fig 15.7. To find the specific gravity of the liquid, float the hydrometer in the liquid. The reading on the stem indicates the specific gravity of the liquid.

Usually, two different hydrometers, one used for liquids denser than water, and the other, for liquids lighter than water are provided.

A common hydrometer used to test the purity of milk by noting its specific gravity is called a LACTOMETER.

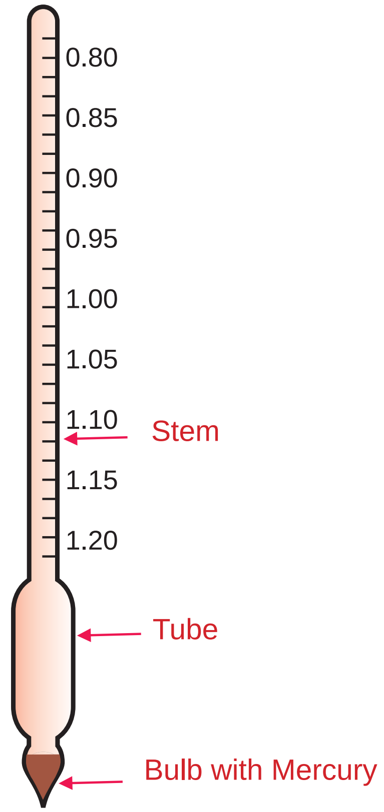
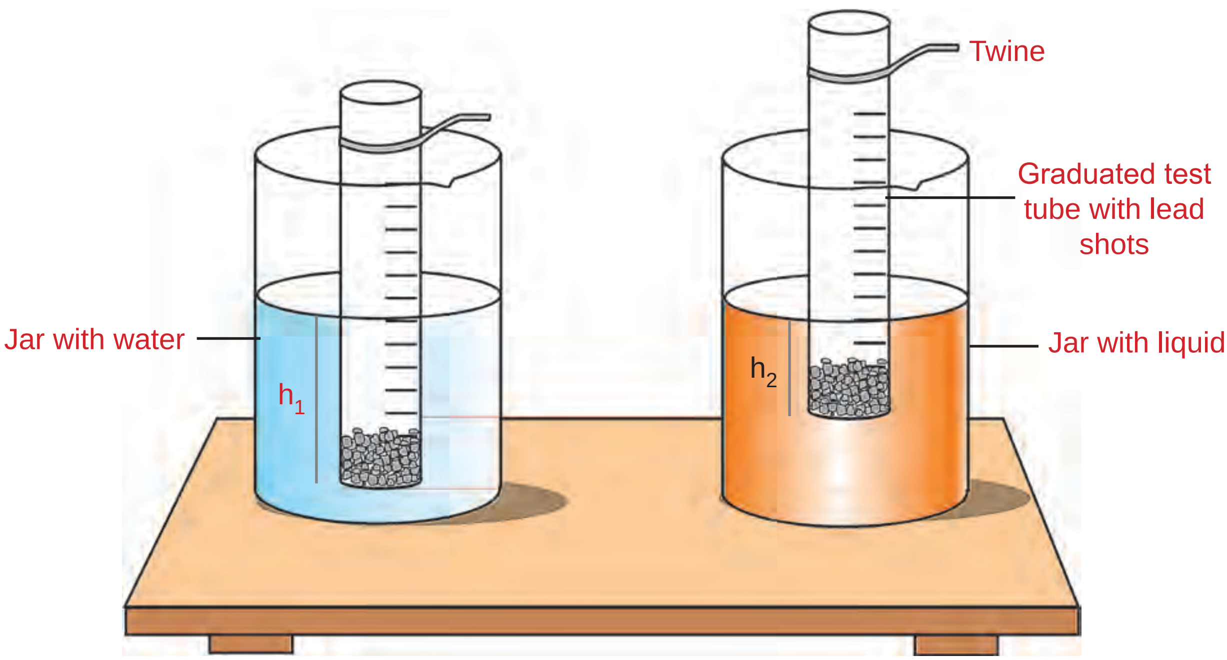


Fig. 15.7. Common hydrometer

Test tube float



A test tube float consists of a flat bottomed test tube of uniform area of cross section. It is graduated in centimetre from the bottom to the top to measure the depth of immersion in a liquid. The float is made heavy by adding lead shots or sand to enable it to float vertically.

Experiment to find the specific gravity of a liquid using a test tube float as a variable immersion hydrometer

Take two tall jars of the same capacity. Fill one of them with water and the other with the given liquid whose specific gravity is to be found.

Take a graduated test tube and add lead shots or sand to make it heavy so that it floats vertically.

Tie a long thread near the mouth of the test tube to enable us to lower the float in to the jar. Immerse the loaded float first in the jar of water. Take care that the float does not touch the sides or bottom of the jar and there should be no air bubbles sticking to the sides of the float. Note the depth of immersion in water (h_1) without parrallax error. Gently take the float out from the water . Wipe the water droplets on the sides with a clean cloth.

Now gently lower the float into the jar containing the liquid.(Do not add or remove any lead shots). Note the depth of immersion of the float in the liquid (h_2).

Specific gravity of the liquid =

$$\frac{\text{Depth of immersion of the float in water}}{\text{Depth of immersion of the float in liquid}}$$

$$= \frac{h_1}{h_2}$$

Now add or remove a few lead shots and repeat the experiment.

Note down $h_1$and h_2 in each case .Repeat the experiment and tabulate the readings.

Take the average value of $\frac{h_1}{h_2}$ as the specific gravity of the liquid .

Theory

Weight of water displaced = ah_1d_1g

Weight of liquid displaced =ah_2d_2g

Where, a-area of cross section of the float

d_1-density of water

d_2-density of liquid

g-acceleration due to gravity

Since the weight of the test tube float is the same in both the cases

Weight of liquid displaced=weight of water displaced

$$ah_2d_2g = ah_1d_1g$$

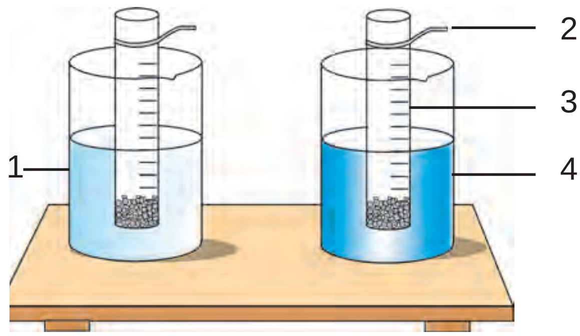
$$\frac{d_2}{d_1} = \frac{h_1}{h_2}$$

Specific gravity of the liquid = $\frac{h_1}{h_2}$

Sl.no	Depth of immersion of the float		Specific gravity of the liquid = $\frac{h_1}{h_2}$ (no unit)
	in water (h_1) cm	in liquid (h_2) cm	
1			
2			
3			
4			
5			

Experiment to find the specific gravity of a liquid using a test tube float as a constant immersion hydrometer

Make the test tube float to float in water vertically to a certain height 'h'. Take care that the test tube float does not touch the sides or bottom of the jar . Take the float out and wipe the outside dry. Find the weight of the float in water(w_1) . Now make the test tube float to float in the given liquid. Add or remove lead shots so that it floats to the same depth 'h'. Take the test tube float out , wipe the outside dry. Find the weight of the float in liquid (w_2).Repeat the experiment for different depths and tabulate the readings.



1. Jar with water 2. Twine
3. Graduated test tube with lead shots
4. Jar with liquid

S.no	Weight of the float		Specific gravity = $\frac{w_2}{w_1}$ (no unit)
	In water (w_1) kg	In liquid (w_2) kg	
1			
2			
3			
4			

As the depth of immersion of the float is the same in both cases , the volume of water and the liquid displaced are same. According to the law of floatation the weight of the floating body is equal to the weight of the liquid displaced.

Weight of the water displaced,$w_1=ahd_1g$ ------------- 1

Weight of liquid displaced,$w_2=ahd_2g$ ------------------ 2

Equ. 2 divided by equ. 1, $\frac{w_2}{w_1} = \frac{d_2}{d_1}$

$$\text{Specific gravity of the liquid} = \frac{\text{weight of the float in liquid}}{\text{weight of the float in water}}$$

ACTIVITY –15.15

Take a water bottle cap. Paste a piece of graph sheet at the side. Take water in one glass tumbler and salt solution in another glass tumbler. Float the cap vertically (add some sand if necessary) in water and in salt solution. Note the depth of immersion. Find the specific gravity of the salt solution. Change the concentration of the salt solution and find the specific gravity at different concentrations.

EVALUATION

Section A

1. Arrange the following speeds in the ascending order.

   (7 m/s, 15 km/h, 2km/minute, 0.1 m/millisecond)

2. When a body rotating along the circular path has unit linear velocity, its angular velocity is equal to ______________ of the circular path.

   (the radius, square of the radius, reciprocal of the radius, square root of the radius)

3. If a body start from rest, the acceleration of the body after 2 second is _______ of its displacement.

   (half, twice, four times, one fourth)

4. The gradient or slope of the distance-time graph at any point gives ______.

   (acceleration, displacement, velocity, time)

5. The area under the velocity-time graph represents the _______ the moving object.

   (velocity of, displacement covered by, acceleration of, speed of)

6. In a 100 m race, the winner takes 10 s to reach the finishing point. The average speed of the winner is ______

   (5 m/s, 10 m/s, 20 m/s, 40 m/s)

7. Pick out odd one from the following with respect to the properties of a liquid.

   a) They have definite volume. b) Liquids are incompressible.

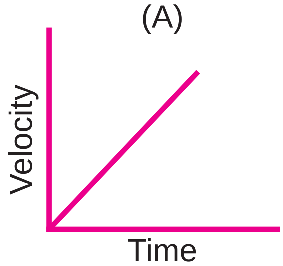
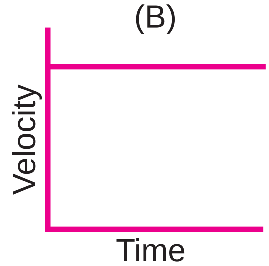
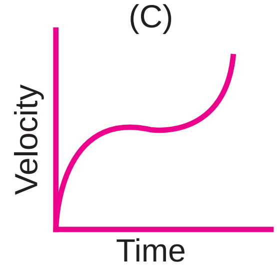
   c) They have their own shape.

Section B

8. Complete the table from the list given below;
   (m/s, rad/s^2, rad, m/ s^2, rad/s)

Sl. No	Physical quantity	Unit
1	Velocity	
2	Acceleration	
3	Angular displacement	
4	Angular velocity	

9. i) Match the following graph with their corresponding motion.

<table>
<tr><th>Motion</th><th>a) Unaccelerated motion</th><th>b) Non-uniformly accelerated motion</th><th>c) Uniformly accelerated motion</th></tr>
<tr><td>Graph</td><td>(A)

</td><td>(B)

</td><td>(C)

</td></tr>
</table>

ii) What is the value of acceleration in graph 'B'?

10. A motorcycle traveling at 20 m/s has an acceleration of 4 m/s^2. What does it explain about velocity of the motorcycle?

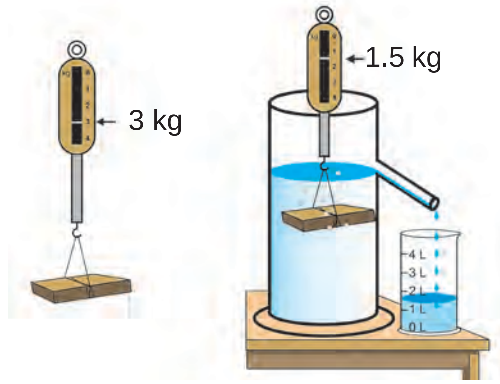
11. A bus travels a distance of 20 km from Chennai Central to Airport in 45 minutes.

    i) What is the average speed? ii) Why actual speed differs from average speed?

12. Analyze the diagram and answer the following

    i) What is the apparent loss in weight of the block inside the water?

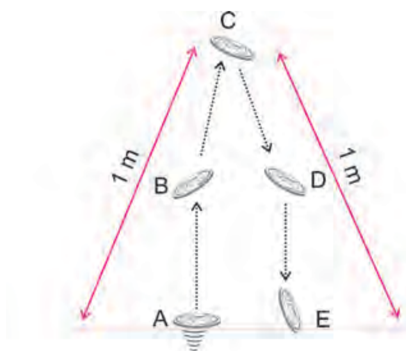
    ii) What do you infer from the diagram?



13. Statement. 'In uniform circular motion, the magnitude and direction of velocity at different points remain the same', check whether the above statement is correct or incorrect. Reason out.

Section C

14. A coin is tossed with a velocity 3 m/s at A.

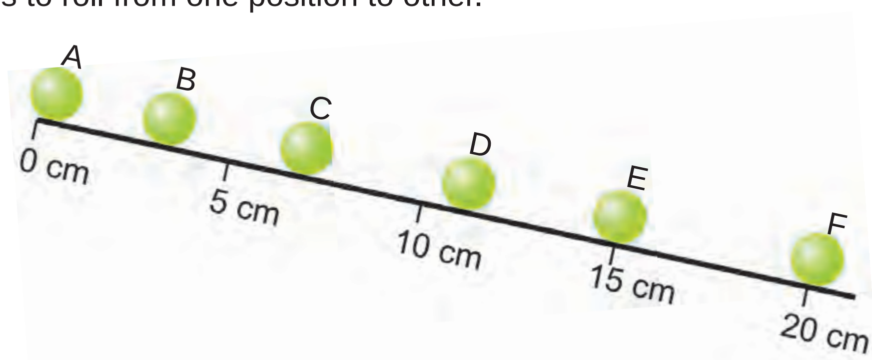


    a) What happens to the velocity along AB, along DE and at C?

    b) What happens to acceleration of the coin along AC and CE?

    c) The distance and vertical displacement covered by the coin between A & E.

15. The diagram shows the position of a ball as it rolled down a track. The ball took 0.5 s to roll from one position to other.



    a) State whether the motion of the ball is uniform or non-uniform motion.

    b) What is the distance travelled by the ball in 2.5 s?

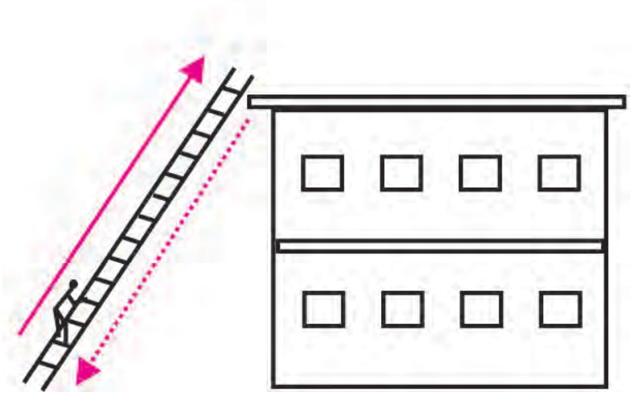
    c) Find the average velocity of the ball from A to F.

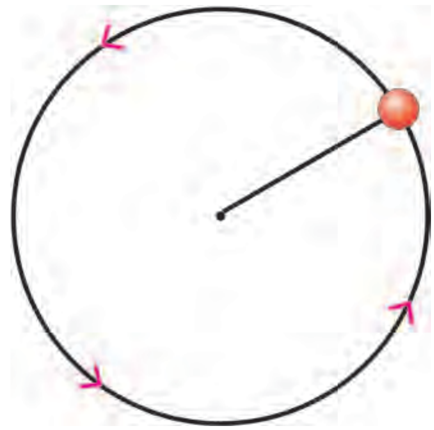
16. Consider the motions in the following cases.

(i) moving car

(ii) a man climbed to terrace and got down

(iii) ball completed one rotation





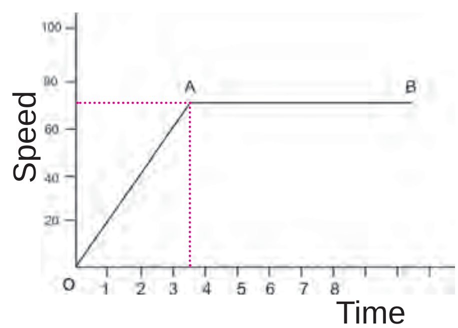
a) In which of the above cases the displacement of the object may be zero.

b) Justify your answer.

17. The following graph shows the motion of a car.

a) What do you infer from the above graph along OA and AB?

b) What is the speed of the car along OA and along AB?



18. Derive the three equations of motion by graphical method.

FURTHER REFERENCE

Books

1. General Physics - Morton M. Sternhein - Joseph W. Kane - JohnWiley
2. Fundamentals of Physics – David Halliday & Robert Resnick – JohnWiley

Websites

http://www.futuresouth.com

http://www.splung.com

Chapter 16

WORK, POWER, ENERGY AND HEAT

WORK, POWER, ENERGY AND HEAT

One day Kumar went to see his father at their paddy field. Workers were loading paddy bags into a lorry. He saw the worker Ramu loading as many as 32 bags in an hour. But, at the same time, Somu loaded only 26 bags. He asked his father why was it so? Father replied that, Ramu has more energy compared to Somu. Because of that only the difference arose. Let us help Kumar and others to understand more about energy, work and power in a detailed manner.

16.1. WORK

The meaning of work in our daily life is different from that of physics.

Anything that makes us tired is known as work. For example, reading, writing, painting, walking, etc.

In physics work (W) is said to be done, when a force (F) acts on the body and point of application of the force is displaced (s) in the direction of force.

work done = force x displacement

W = F s

(i) If the body is displaced in the same direction of force, work is done by a force as shown in Fig. 16.1.

Fig. 16.1. Work done by a man

(ii) If the displacement is against a force, the work is done against the force.

(iii) If the displacement is perpendicular to the direction of the force, work done is zero.

Unit of work

Unit of work is joule (J). One joule of work is said to be done when a force of 1 newton acting on a body displacing it by a distance of 1 m.

Larger units of work are

i) kilojoule (1000 joule)

ii) megajoule (10 lakh joule)

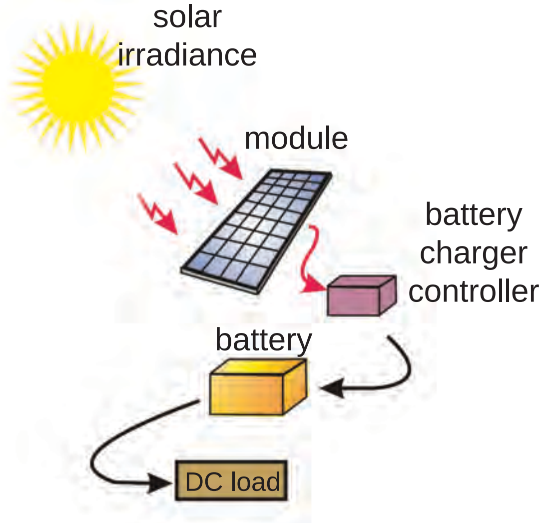
James Prescott Joule

James Prescott Joule was an outstanding British physicist. He is best known for his research in electricity and thermodynamics. Amongst other things, he formulated a law for heating effect of electrtic current. He also verified experimentally the law of conservation of energy and discovered the value of mechanical equivalent of heat. The unit of energy and work called joule, is named after him.

16.2. ENERGY

Life is impossible without energy. The demand for energy is ever increasing. Living things and machines need energy in order to work.

The energy of the body is defined as its capacity to do work.



Solar energy

ACTIVITY –16.1

List some energy sources.

1. Sun. 2......................

3..................... 4. ....

Unit of energy

Energy is measured in terms of work. Unit of energy is also joule. One joule of energy is required to do one joule of work.

Different forms of energy

We live in a world where we have energy in many different forms. Some important forms of energy are mechanical energy, chemical energy, light energy, heat energy, electrical energy, nuclear energy and sound energy.

Mechanical Energy

The energy used to displace a body or to change the position of the body or to deform the body is known as mechanical energy.

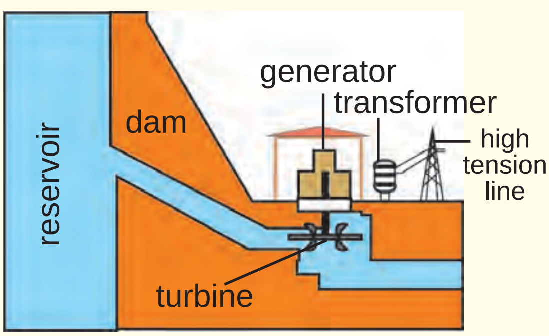
Mechanical energy is of two types i) Potential energy ii) Kinetic energy.

16.2.1. POTENTIAL ENERGY

The energy possessed by a body by virtue of its position or due to state of strain, is called potential energy.

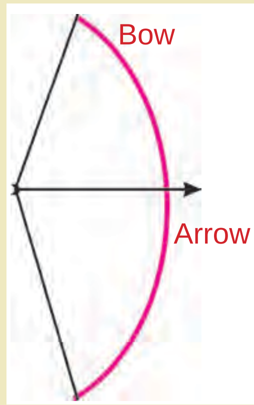
The work done to lift a body above the ground level gives the potential energy of the body. Eg. weight lifting.

Example: Water stored in reservoir has large amount of potential energy due to which it can drive a water turbine when allowed to fall down. This is the principle of production of hydro electric energy.



Hydropower Station

ACTIVITY –16.2



Bow and Arrow

Take a bamboo stick and make a bow. Place an arrow made of a light stick with one end supported by stretched string. Now stretch the string and release the arrow, which flies off. Note the change in the shape of the bow.

The potential energy stored in the bow due to the change of shape is used in the form of kinetic energy in the movement of the arrow.

Expression for potential energy of a body above the ground level

Work is done in raising an object from the ground to certain height against the gravity is stored in the body as a potential energy.

Consider an object of mass m. It is raised through a height h from the ground. Force is needed to do this.

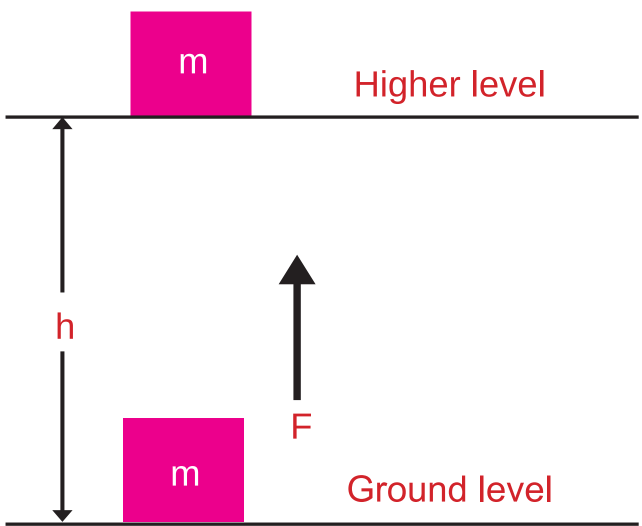


Fig. 16.2.

The downward force acting on the body due to gravity = mg.

The work has to be done to lift the body through a height h against the force of gravity as shown in Fig 16.2.

The object gains energy to do the work done (w) on it.

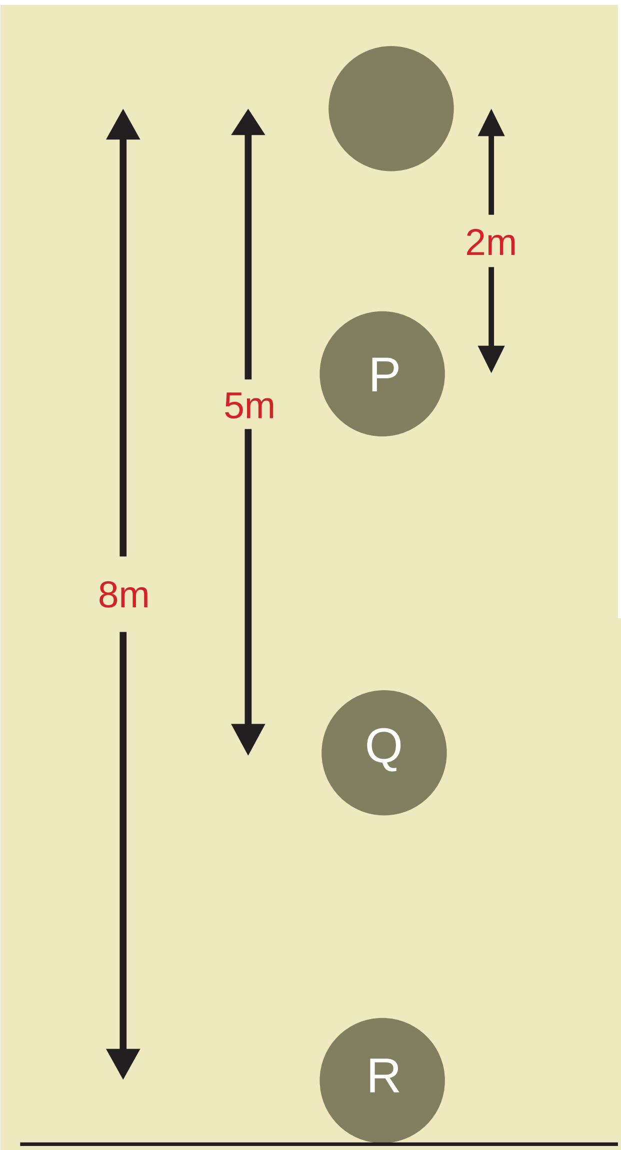
work done = force x displacement

w = F x h   Since F=ma

w = mgh   a=g F=mg

Work done is equal to potential energy of an object.

E_p = mgh.



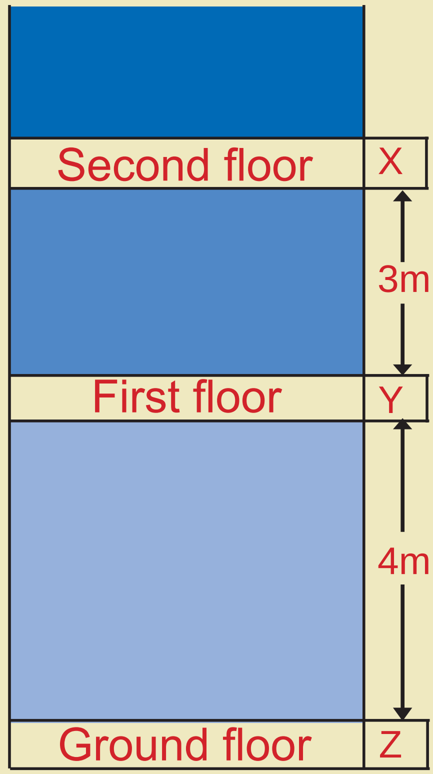
ACTIVITY –16.3

Find the value of potential energy at different points. m = 10 kg and g = 10 ms^{-2}

i. $E_p(X)$ = ___________

ii. $E_p(Y)$ = ___________

iii. $E_p(Z)$ = ___________



ACTIVITY –16.4

Find the potential energy of a ball with respect to position P,Q and R. Take m = 5 kg and g = 10 ms^{-2}

i. Ep(P) = ___________

ii. Ep(Q) = ___________

iii. Ep(R) = ___________

Understand that potential energy of a body at a point is different for different levels.

16.2.2. KINETIC ENERGY

Energy possessed by an object due to its motion is called kinetic energy.

Kinetic energy of an object increases with its speed. Kinetic energy of an object moving with a velocity is equal to the work done on it to make it acquire that velocity.

Example-1 Kinetic energy of a hammer is used to drive a nail into the wall.

Example-2 Bullet fired from a gun can penetrate into a target due to its kinetic energy.

Expression for kinetic energy

Let a body (ball) of mass m is moving with an initial velocity v. If it is brought to rest by applying a retarding (opposing) force F, then it comes to rest by a displacement S. Let,

E_k = work done against the force used to stop it.

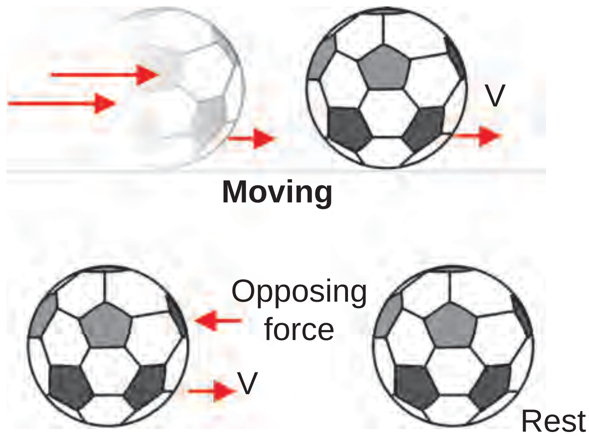
$E_k = F . S$ -----> (1)

But retarding force F = ma-----> (2)

Let initial velocity u = v, final velocity v = 0

From III equation of motion

$$v^2 = u^2 + 2aS$$



applying, $0 = v^2 - 2aS$ ($\because$ a is retardation)

$$2aS = v^2$$

displacement, $S = \frac{v^2}{2a}$ ----> (3)

substituting (2) and (3) in (1)

$$E_k = ma \times \frac{v^2}{2a}$$

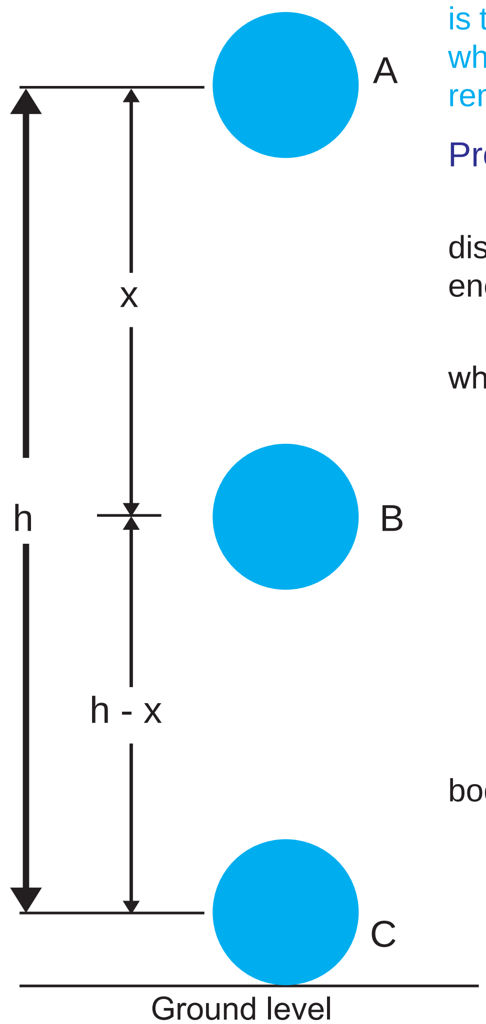
$$E_k = \frac{1}{2} mv^2$$

16.3. LAW OF CONSERVATION OF ENERGY

ACTIVITY –16.5

A steel ball of mass 5 kg (namely shot put) is dropped from a height of 5 m. Find and fill the table. (take $g = 10\ ms^{-2}$ for easy calculation)

Height of steel ball above the ground m	potential energy $E_p = mgh$ J	Kinetic energy $E_k = \frac{1}{2} mv^2$ J	Total energy $E = E_p + E_k$ J
5			
4			
3			
2			



Energy can neither be created nor destroyed, but it is transformed from one form to another. Alternatively, whenever energy gets transformed, the total energy remains unchanged.

Proof – Freely falling body

It may be shown that in the absence of external dissipative forces (frictional force) the total mechanical energy of a body remains constant.

Consider a body of mass m falls from a point A, which is at a height h from the ground as shown in fig.

At A,

Kinetic energy $E_k = 0$

Potential energy $E_p = mgh$

Total energy $E = E_p + E_k$

$= mgh + 0$

$E = mgh$

During the fall, the body is at a position B. The body has moved a distance x from A.

At B,

velocity $v^2 = u^2 + 2as$

applying, $v^2 = 0 + 2ax = 2gx$ ($\because a = g$)

Kinetic energy $E_k = \frac{1}{2} mv^2$

$$= \frac{1}{2} m \times 2gx$$

$$= mgx$$

Potential energy $E_p = mg(h - x)$

Total energy $E = E_p + Ek$

$$= mg(h-x) + mgx$$

$$= mgh - mgx + mgx$$

$$\mathbf{E = mgh}$$

If the body reaches the position C.

At C,

Potential energy $E_p = 0$

Velocity of the body C is

$$v^2 = u^2 + 2as$$

$$u = 0, a = g, s = h$$

applying $v^2 = 0 + 2gh = 2gh$

kinetic energy $E_k = \frac{1}{2} mv^2 = \frac{1}{2} m \times 2gh$

$$E_k = mgh$$

Total energy at C

$$E = E_p + E_k$$

$$E = 0 + mgh$$

$$\mathbf{E = mgh}$$

Thus we have seen that sum of potential and kinetic energy of freely falling body at all points remains same.

Under the force of gravity, the mechanical energy of a body remains constant.

16.4. RATE OF DOING WORK (OR) POWER

ACTIVITY –16.6

Think and find which one of the following will have more power - Bike, Car, Bus and Aeroplane. why?.

Power is defined as the rate of doing work or work done per unit time.

$$\text{Power} = \frac{\text{work done}}{\text{time taken}}$$

$$P = \frac{w}{t}$$

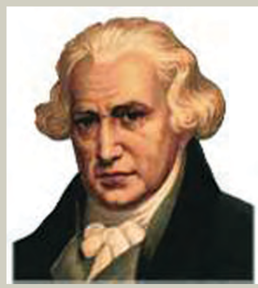
16.5. UNIT OF POWER

The unit of power is J/S known as watt, its symbol is W.

$$1 \text{ watt} = \frac{1 \text{ joule}}{1 \text{ second}}$$

$$1 \text{ W} = 1 \text{ J S}^{-1}$$

James Watt (1736-1819)



A Scottish inventor and mechanical engineer whose improvements to the steam engine were fundamental to the changes brought by the industrial revolution in the world.

Watt was interested in the technology of steam engines. He realised that contemporary engine designs wasted a great deal of energy by repeatedly cooling and reheating the cylinder. Watt introduced a design enhancement, the separate condenser, which avoided this waste of energy and radically improved the power, efficiency and cost effectiveness of steam engines. He developed the concept of horsepower. The SI unit of power, the watt, was named after him.

Commercial unit of energy is kilo watt hour

We pay electricity bill in terms of unit or kWh. It is a commercial unit of electric energy consumed by the user.

Watt hour = power in watt x time in hour.

Example : How much energy will be used when a hundred watt bulb is used for 10 hour?

Energy = 100 watt x 10 hour

= 1000 w h = 1kw h

I kwh is known as 1 unit.

One kilowatt hour means thousand watt of power is consumed in one hour.

$$1 \text{ kWh} = 1 \text{ kW} \times 1 \text{ h}$$
$$= 1000 \text{ W} \times 60 \times 60 \text{ s}$$
$$= 1000 \text{ Js}^{-1} \times 3600 \text{ s}$$
$$= 3.6 \times 10^6 \text{ J}$$

1 unit = 1 kilowatt hour = 3.6×10^6 J

Try this

How long can a 40 watt bulb glow in order to consume 1 unit of energy?

How much energy is consumed, when a motor of 500 W power runs for 4 hour?.

Energy Transformation

Water from dam:	Potential energy into Kinetic energy
Microphone :	Sound energy into Electrical energy
TV Camera :	Light energy into Electrical energy
Solar Cell :	Light energy into Electrical energy
Iron Box :	Electrical energy into Heat energy
Loud speaker :	Electrical energy into Sound energy
Fan :	Electrical energy into Mechanical energy
Light :	Electrical energy into Light energy

ACTIVITY –16.7

Find and write the power (in watt) consumed by following electrical appliances at your home.

- Tube light............................
- Ceiling fan...........................
- Mixi....................................
- Grinder.................................
- Water heater.........................
- Air conditioner......................
- ....
- ....
- ....

16.6. HEAT

We know that heat is a form of energy. The degree of hotness or coldness is given by temperature. Will the temperature give the amount of heat energy possessed by a body?

No, the temperature alone cannot give any idea about the heat energy. Then, how to measure the heat?

Heat is commonly experienced by everybody just as easily as one feels the weight of an object. But the measurement of heat is not as simple as the measurement of weight. Heat can only be measured in terms of the effects it produces.

ACTIVITY –16.8

Take three identical hard glass beakers. Take 50 ml of water in the 1st beaker, 75 ml of water in the 2nd and 100 ml in the 3rd. Note their initial temperatures. Heat the beakers one by one using spirit lamp for a certain period of time (say 5 minutes). Note the rise in temperature in each case (Here we have supplied the same amount of heat).

In the activity-16.8, will the rise in temperature be same?

No, the rise in temperature is not the same in the three cases.

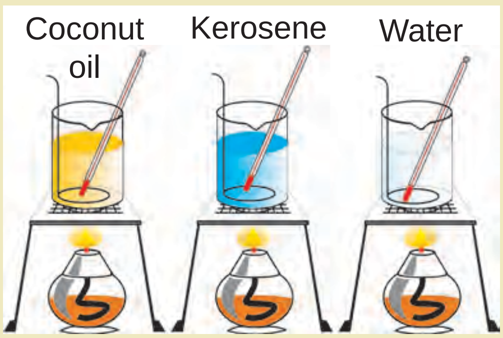
Inferences

The same amount of heat supplied to different masses of same material will not give the same rise in temperature. But we can see the product of the mass and the rise in temperature will remain the same for all.

Therefore the product of mass and rise in temperature can be taken as the measure of the quantity of heat.

ACTIVITY –16.9

Take three identical beakers and fill them with equal mass of water, kerosene and coconut oil. Note their initial temperatures. Using spirit lamps heat the three beakers for five minute. Observe the difference in the rise of temperature of different liquids.



Inference

The rise in temperature depends on the nature of the substance.

What do you infer from these activities?

The rise in temperature depends on mass and nature of the substance.

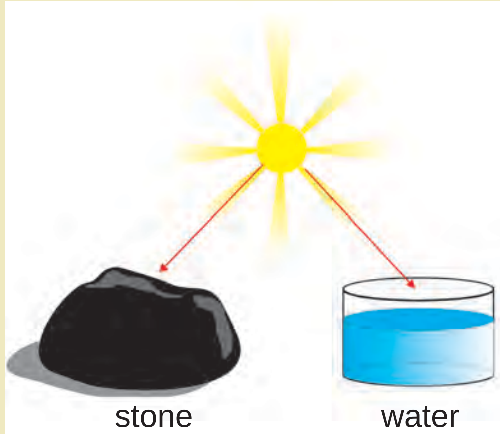
To describe the combined effect of mass and nature of the substance we introduce the term thermal capacity or heat capacity.

16.6.1. THERMAL CAPACITY

Thermal or heat capacity of a body is defined as the amount of heat required to raise its temperature by 1 K.

Its unit is joule / kelvin (J/K or JK^{-1})

ACTIVITY –16.10



Take a stone and water of same mass. Place them in the hot sun for an hour. Now touch the stone with one hand and water with the other hand. Observe that the stone is hotter than water.

From the above activity we understand that heat capacities are different for different substances.

Specific heat capacity (s)

The above activity shows that the heat capacity depends upon the nature of the substance. Different substances of same mass have different heat capacities because of this factor. We take it into account by defining a quantity called specific heat capacity.

The amount of heat energy required to raise the temperature of 1 kg of substance through 1 K.

Its unit is $J\ kg^{-1}\ K^{-1}$

Example

The specific heat capacity of water is 4180 J kg^{-1} K^{-1}.

It means that 4180 joule of heat is required to raise the temperature of 1 kg of water through 1 K.

MORE TO KNOW

Specific heat capacity of water is 30 times that of mercury. i.e., by using the same heat given to water, the temperature of 30 kg mercury can be raised by 1K.

The specific heat capacity of mercury is 140 J kg^{-1} K^{-1}.

Compare the above two specific heat capacities. What do you infer?

Shall we calculate the amount of heat energy possessed by the body?

Consider the following example.

Let us consider that the temperature of 5 kg of mercury is raised by 10 K. How much heat is required? Specific heat capacity of mercury is 140 J kg^{-1} K^{-1}

Heat capacity = heat required to raise the temperature by 1 K

Heat capacity = m s

= 5 x 140 = 700 J K^{-1}

Total heat supplied = heat capacity x rise in temperature

= 700 x 10 = 7000 joule

Total heat supplied = mass x specific heat capacity x rise in temperature

Quantity of heat (Q) = mass (m) x specific heat (S) x increase in temperature (θ)

$$Q = mS\theta$$

16.7. CHANGE OF STATE

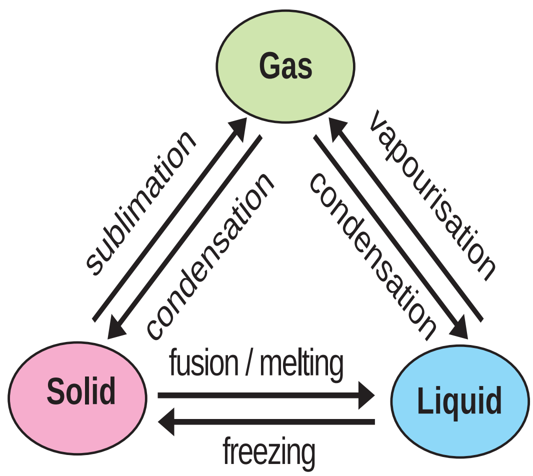
Everyone is familiar with three states of matter – solid, liquid and gas (or vapour). Of these three states, solid state is most familiar.

We are less familiar with the gaseous state of matter even though we are surrounded everywhere by the substance in the gaseous state – the air.

Solid and liquid states are the most predominant form of matter in our planet.

We shall consider the important effects arising out of addition or removal of heat energy. It is common exeperience that many substances change their state on supply or removal of heat energy.

The process of converting a substance from one state to another is called change of state.



Melting

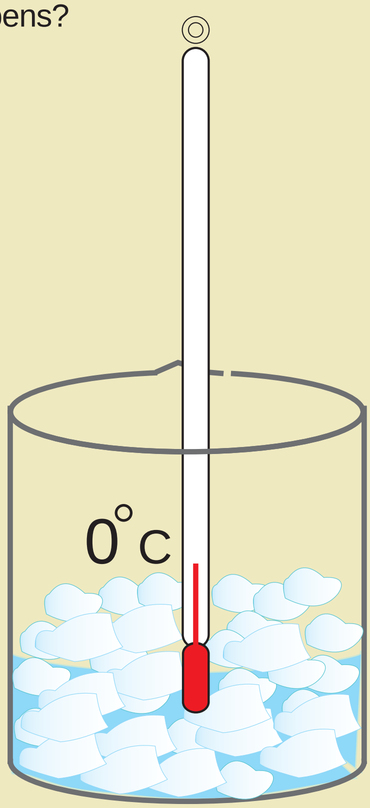
The process in which a substance changes from the solid state into liquid state on heating is called melting or fusion.

Melting point

The constant temperature at which a solid gets converted into its liquid state is called melting point.

ACTIVITY –16.11

Take ice and put it into a container. A thermometer is inserted. What happens?

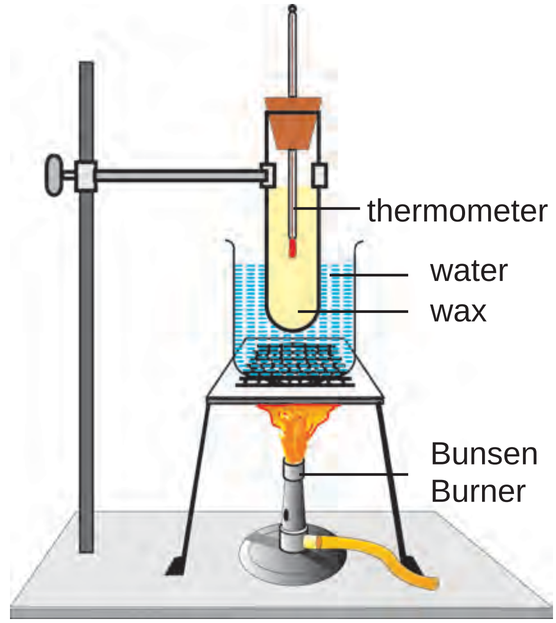


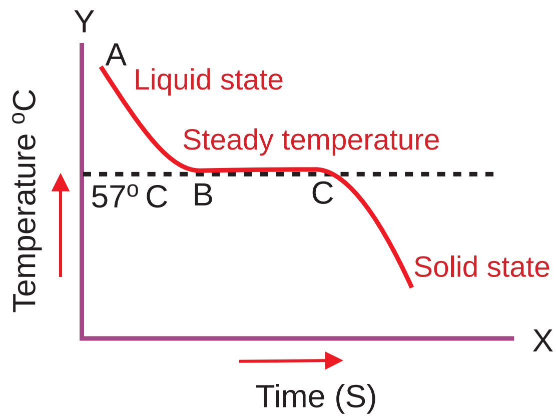
Temperature remains constant at 0°C until an ice melts and changes into water. Ice takes the heat from the atmospheric air and melted. Temperature is found to be 0°C. The change takes place at a temperature called melting point. Therefore the melting point of ice is 0°C.

Melting point of wax

A test tube with sufficient quantity of wax is taken and a thermometer is placed in the test tube through a cork. It is then placed in a beaker containing water. Water is heated till the wax in the test tube melts and gets converted completely into the liquid state.

Heating is stopped and wax is allowed to cool. The temperature of the wax is noted for every one minute till the temperature of wax falls to 30 °C.





A graph is plotted between time along the X axis and temperature along the Y axis. In the graph in the portion AB shows the wax in the liquid state and below C it is in the solid state.

The temperature corresponding to the horizontal line in the graph gives the melting point of wax. At this temperature the liquid wax is converted solid without change of temperature. The melting point of wax is 57° C. When the liquid wax changes into a solid, its volume decreases.

Boiling

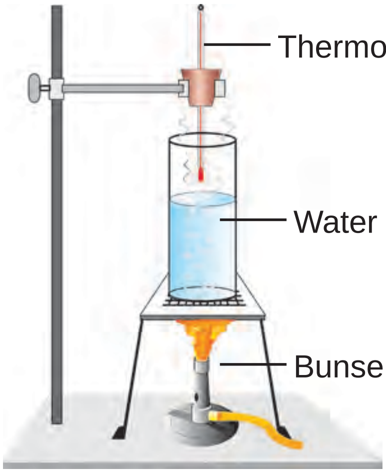
The process in which a substance in its liquid state gets converted into vapour state is called boiling.

Boiling point

The constant temperature at which a liquid is converted into its vapour is known as boiling point.

Boiling point of water

Arrange the apparatus as shown in figure.



Take some water in boiling tube. Fix the thermometer, so that its bulb remains just above the water level. The boiling tube is heated. The mercury in the thermometer rises and remains constant at a temperature 100^o C. This constant termperature is called as boiling point of water.

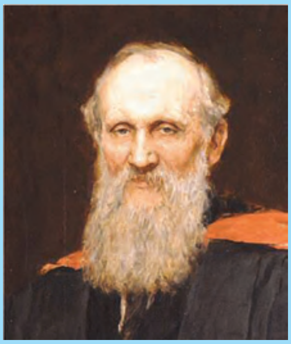
16.8. KELVIN'S SCALE OF TEMPERATURE

If a substance is cooled continuously its temperature decreases but there is a limit to the lowest temperature to which a substance can be cooled.

The lowest possible temperature is taken as zero point of the Kelvin's scale. This temperature is called as absolute zero.This is written as 0 K.

At absolute zero there is no molecular motion and hence no heat energy in a substance. At absolute zero all atomic and molecular motion stop. So absolute zero is the lowest temperature possible and denoted by 0 K or -273^0 C.

Lord Kelvin



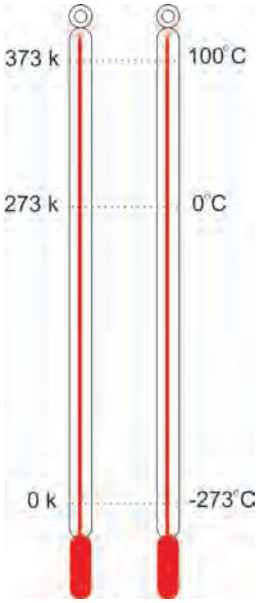
He was a physicist and an engineer. He is widely known for his eminent contribution to thermodynamics. He devised the kelvin scale of temperature. The unit of temperature was named after him to honour his outstanding contribution and achievements.

All objects at all temperature above absolute zero, emit thermal or heat energy.

Kelvin scale (K) = Celsius scale (^{0}C) + 273

Celsius scale (^{0}C) = Kelvin scale (K) – 273

If temperature is expressed in kelvin scale degree symbol is omitted.



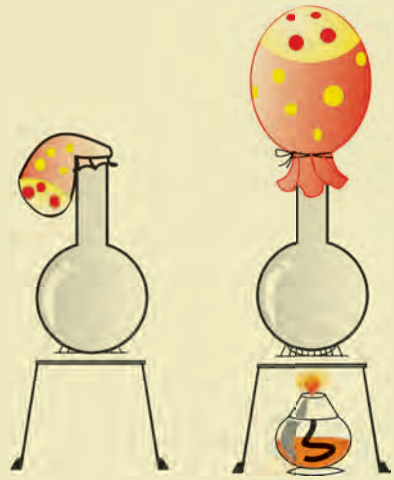
$T_k = T_c + 273$

Celsius, Kelvin scale

Expansion of gases

ACTIVITY –16.12

A balloon is fixed to the mouth of an empty and dry flask. Heat the flask over a flame and observe the balloon. It keeps growing in size on heating continuously. Why does it happen?



The pressure of air inside the flask and hence air inside the balloon increases. (The increase in pressure is due to heating). Stop heating. What happens and why?

It's size decreases which indicates the decrease of pressure.

From the activity 16.12, we infer that the bulging of the balloon is due to increase of pressure of air on heating. We can also infer that the volume of air inside the flask and balloon also increased with temperature.

Supply of heat may produce an increase in both volume and pressure of a gas. In solids and liquids we consider only volume changes.

For gases, we consider changes in volume or pressure or both with temperature.

It is convenient to study the variation of one of them with temperature by keeping the other constant.

In the activity 16.12, we have only the variation of volume with temperature. there is no change in pressure here as air is free to expand against the constant external pressure.

How can we explain the variation of pressure alone with temperature.?

What happens when a metallic container with an air tight lid is heated?

The volume is constant and pressure will be increasing. If the container is strongly heated, the lid may not be able to withstand the large pressure and may blow off.

Robert Boyle is best known for his work in physics and chemistry. He formulated Boyle's law. He is regarded as the first modern chemist. He described the element as primitive simple and perfectly complete bodies. From 1661 the term element has been reserved for material substances.

16.9. GAS LAWS & GAS EQUATION

Gas laws

The expansion of gas is usually due to variation of pressure, volume and temperature. Finding the relation between the any two by keeping third one constant, are known as gas laws.

The relation can be the change in pressure and volume by keeping temperature constant, called Boyle's law.

Boyle's law.

At constant temperature, the pressure of a given mass of gas is inversely proportional to its volume.

If P is the pressure, V is the volume at constant temperature,

$$p \propto \frac{1}{v} \qquad pv = \text{a constant}$$

Charle's law

The relation between volume and temperature by keeping pressure constant, is called Charles law or law of volume.

Law of volume: At constant pressure, the volume (v) of a given mass of gas is directly proportional to its absolute temperature (T).

$$v \propto T, \qquad \frac{v}{T} = \text{a constant}$$

The relation between pressure and temperature by keeping volume constant, is called Charles law or law of pressure.

Law of pressure: At constant volume, the pressure (p) of a given mass of gas is directly proportional to its absolute temperature (T).

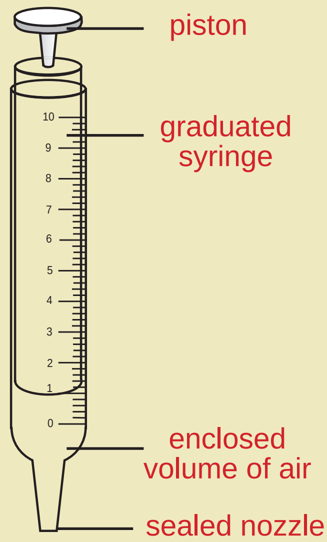
$$p \propto T, \qquad \frac{p}{T} = \text{a constant}$$

Jacques Charles (1746 – 1823)

He was a French inventor, scientist, mathematician, balloonist and Professor of Physics in Paris. He found the relation between the temperature and volume. His experiment revealed that all gases expand and contract to the same extent when heated through the same temperature intervals. He constructed the first hydrogen balloon, which brought him popular fame and royal patronage. He also invented hydrometer.

ACTIVITY 16.13

Take a transparent syringe and seal its nozzle. Push down the piston and slowly release it as shown in fig. observe what happens.



Gas equation: The gas equation is relating the pressure, volume and temperature of perfect gas, which obeys Boyle's law and Charle's law.

Let p – pressure, v – volume,

T – Temperature

using Boyle's law, T is constant

$$p \propto \frac{1}{v}$$

using Charle's law

v is constant, $p \propto T$

using both the laws we get

$$p \propto \frac{T}{v} \qquad pv \propto T$$

$$pv = RT$$

where R is proportional constant, and is known as gas constant.

The value of $R = 8.31\ J\ mol^{-1}\ K^{-1}$

If n is the number of mole in the gas,

$$pv = nRT$$

It is the perfect gas equation.

EVALUATION

Section – A

1. Work done by the force is said to be negative, if the displacement of a body is _________. (along the force, against the force)

2. The degree of hotness or coldness of a body is ________ (heat, temperature).

3. Pick the odd one out from the following based on the nature of energy possessed by them.

   (moving car, water stored in a tank, a book on a table, ceiling fan in OFF position)

4. Commercial unit of electrical energy is _______ .

   (joule, joule/second, watt, kilowatt hour)

5. Select the liquid from the following which has the specific heat capacity of 4180 $JKg^{-1}K^{-1}$.

   (mercury, kerosene, water, coconut oil)

Section – B

6.

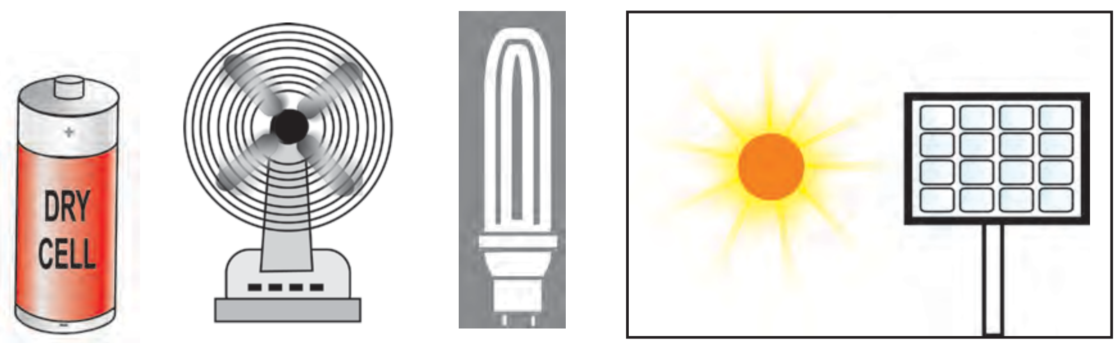
(i) (ii) (iii)

Observe the above figures, state and explain in each case whether work is done or not?

7. What is the work done by the force of gravity on a satellite moving around the earth? Justify your answer.

8. Now-a-days copper bottom vessels are used for cooking rather than other metals. Why?

9. See the following pictures. Mention the nature of energy transformation.



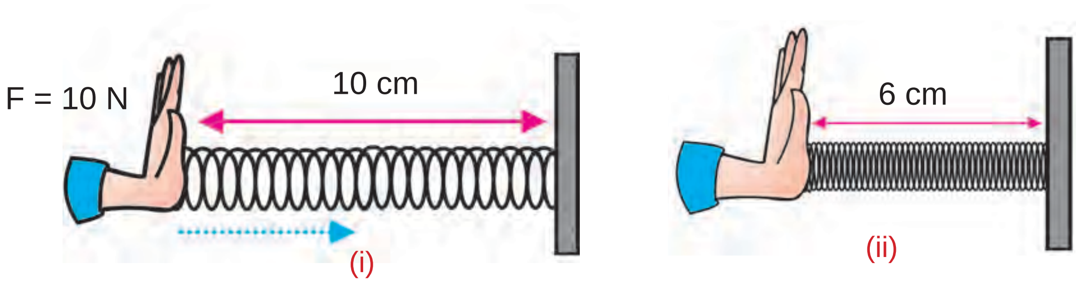
(i) (ii) (iii) (iv)

10. Match the following

Change of state	Examples
1) vapourisation	a) burning of champhor
2) condensation	b) water changed into ice
3) freezing	c) steam
4) sublimation	d) rain

11. Raja weighing 40 kg claims up on a staircase of 20 steps, each with 16 cm height in 20 second. Find his power.

12. See the diagrams, Calculate the potential energy stored in the compressed spring?



13. The boiling point of water is 100^oK. Identify the mistake(s) in the above statement and correct it in Kelvin scale.

14. Complete the following table by choosing the right answer given below.

(mechanical energy, microphone, loudspeaker)

Sl. No	Energy transformation		Device
	From	To	
1	Electrical energy		Motor
2	Sound energy	Electrical energy	

Section – C

15. Kala is doing an experiment in science laboratory to determine the melting point of wax by cooling curve method. She recorded the temperature of melted wax as below

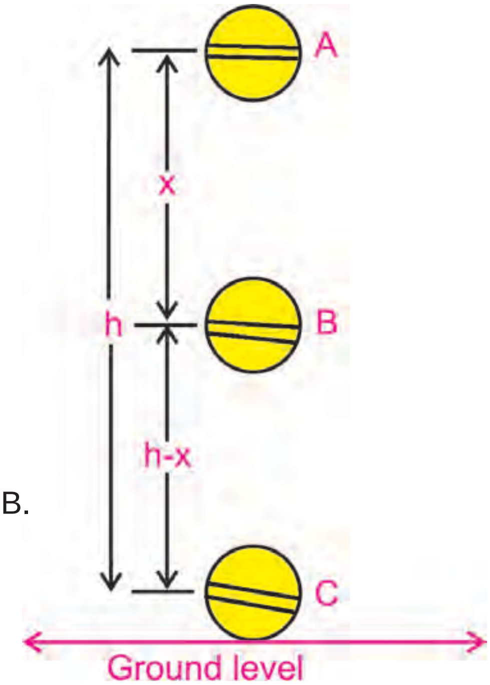
a) Draw a cooling curve by taking time along the x-axis and temperature along the y-axis.

b) Find the melting point of wax from the cooling curve.

c) What is the state of wax along the flat portion of the curve?

Time (minute)	Temperature (^oC)
0	85
1	80
2	70
3	60
4	57
6	57
7	57
8	54
9	48

16. Consider the case of freely falling body given in the following figures



At A

Kinetic energy=0

Potential energy=mgh

At B

Kinetic energy=mgx

At C

Kinetic energy=mgh

Potential energy=0

a) Find the potential energy of the body at B.

b) Find the total energy at A,B and C.

c) Is there any variation in total energy? What do you infer from the result?

17. Describe an experiment to determine melting point of wax.

FURTHER REFERENCE

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2. Complete Physics for IGCSE – Oxford publications

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Chapter 17

SOUND

SOUND

Meena and her parent went for a wedding reception, she saw the members of the orchestra adjusting their instruments by plucking, tapping, beating, etc,. before the music programme began. Meena asked her father why they did such things? Father explained that by doing such adjustments they get proper vibrations and music. Let us help Meena and others to understand more about sound.

17.1. PRODUCTION OF SOUND

Sound has great importance in our daily life. Sound makes it possible for us to communicate with one another through speech.

- Musical sound gives us pleasure.
- Radio and television sound gives us information and entertainment.
- Horn sound of vehicles alert us.

ACTIVITY –17.1

Pluck the string of the Veena or the Guitar. Rub the Violin string. See the vibrating string and hear the sound.


Veena


Violin


Guitar

ACTIVITY –17.2

(i) Ring the bell / set the alarm clock and hear the sound.

(ii) Beat a drum with its stick and hear the sound.


Bell


Drums


Alarm Clock

ACTIVITY –17.3

(i) Blow a whistle

(ii) Press the horn and hear the sound.


Whistle


Horn

From the above activities, we understand that we can produce sound by scratching, rubbing, blowing, plucking, hitting and shaking different objects. All these activities set the objects vibrating, they make the surrounding air particles to vibrate and produce sound. Vibrations are small to and fro motion of objects.

ACTIVITY –17.4

Make a list of all the sounds you can think of and fit them into their families.

Sl. No.	Being Rubbed	Being blown	Being Plucked	Being hit
1.	Violin	Whistle	Guitar	Drums
2.				
3.				
4.				

17.2. PROPAGATION OF SOUND

ACTIVITY –17.5

Throw a stone into a pool of water. See the circular waves spread out from the point of disturbance and travel outward on the surface of water as shown in figure.

Sound travels through a medium from the point of generation to the listener. Sound waves travel along the to and fro movement of the vibrating objects that produce them.

Medium

The matter or substance through which sound is transmitted is called a medium. It can be a solid, liquid or gas.

Robert Boyle, the scientist, proved that sound cannot pass through vacuum or empty space. He kept an electric bell. Inside a glass container, as shown in fig 17.1. By removing the air slowly from the container using vacuum pump, the volume of sound decreases and no sound is heard when the air is removed completely. By allowing the air back to the container the sound is heard again.

A wave is a disturbance that moves through a medium when the particles of the medium set neighboring particles into motion. They, in turn, produce similar motion in others. The particles of the medium do not move forward, but the disturbance is carried forward, similar to the propagation of sound in a medium.

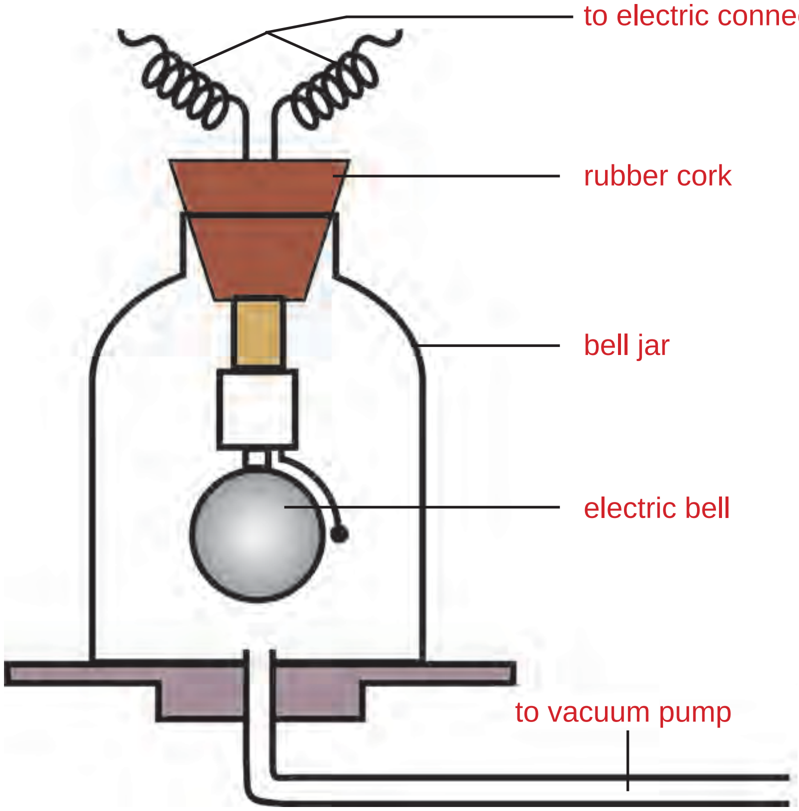
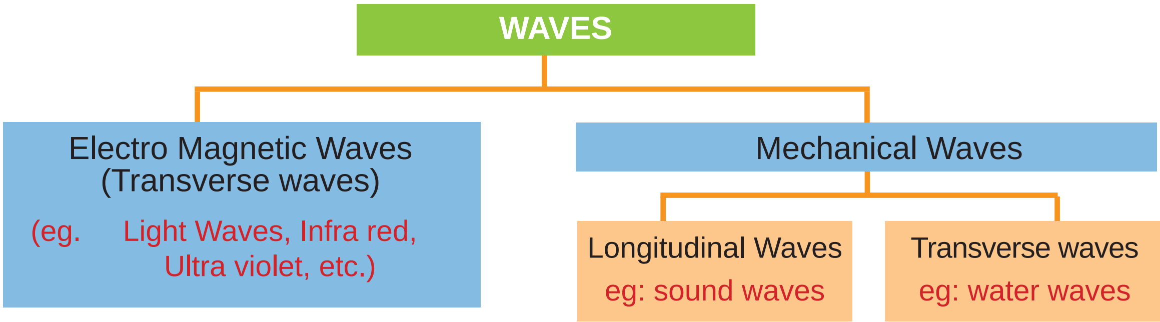


Fig. 17.1.Electric bell in jar

17.3. LONGITUDINAL AND TRANSVERSE WAVES

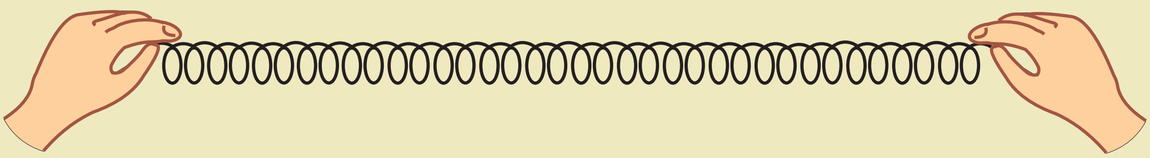


Longitudinal Waves

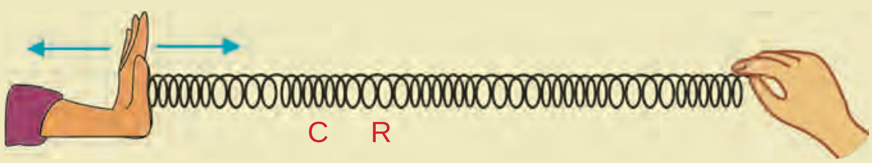
ACTIVITY –17.6

Take a spring. Hold one end and ask your friend to hold other end.

Stretch the spring as shown in fig.



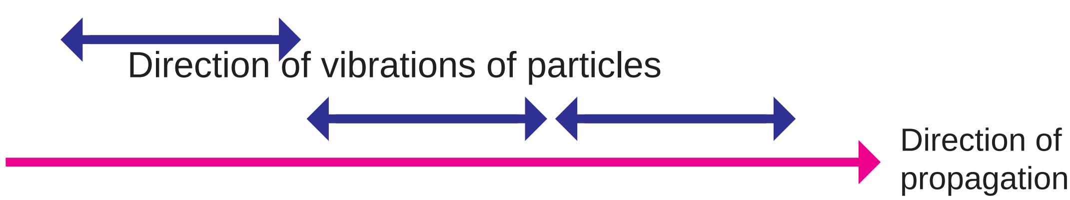
Now push the spring towards your friend. Move your hand for pushing and pulling the spring alternatively. You can see the spring as shown in fig.



C – Compression R - Rarefaction

"If the particles of a medium vibrate in a direction, parallel to or along the direction of propagation of wave, it is called longitudinal wave"

Example: sound waves



Sound waves in air or gases travel in the form of longitudinal waves.

Longitudinal wave propagate in a medium in the form of compression and rarefaction as shown fig 17.2.

Compression is the area with maximum pressure, rarefaction is the area with minimum pressure.

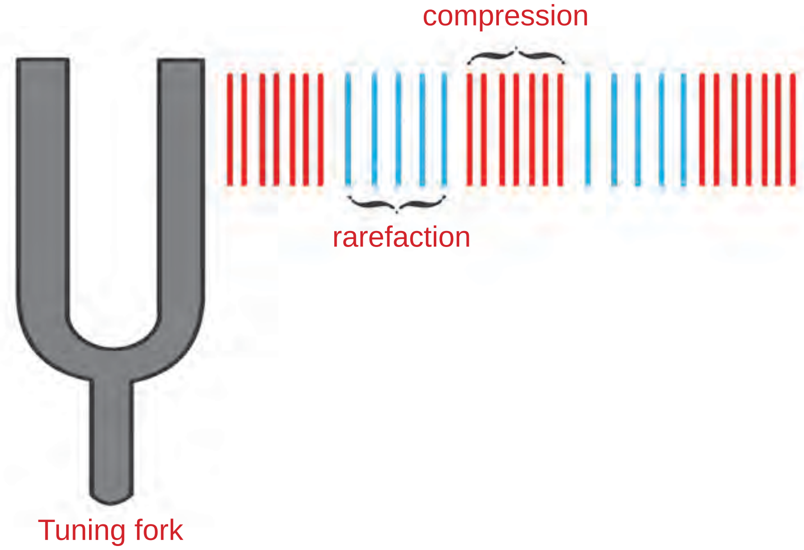
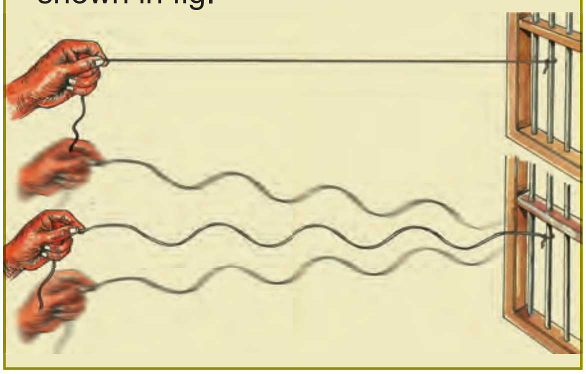


Fig. 17.2. Longitudinal waves

Transverse waves

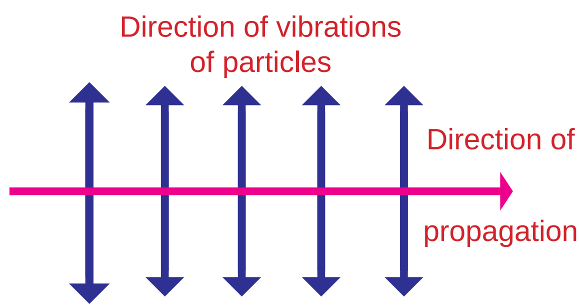
ACTIVITY –17.7

Stretch a long rope with one end fixed and hold the other end firmly. Jerk your hand up and down. You can see an up and down movements and forming transverse wave as shown in fig.



Crest : The maximum displacement along the upward direction.

Trough: The maximum displacement along the downward direction.



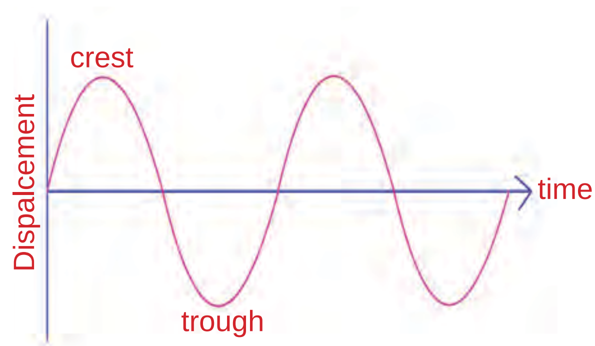


Fig 17.3. Transverse waves

"If the particles of the medium vibrate in a direction, perpendicular to the direction of propagation, the wave is called transverse wave."

Example: water waves, vibrations of stretched string.

Transverse waves propagate in a medium in the form of crests and troughs as shown in fig 17.3.

Difference between Transverse and Longitudinal waves

Transverse waves	Longitudinal waves
Particles of the medium vibrate in a direction which is perpendicular to the direction of propagation.	Particles of the medium vibrate in a direction which is parallel to the direction of propagation.
Crests and troughs are formed	Compressions and rarefactions are formed.
Can travel through solids and surfaces of liquid.	Can travel through solids, liquids and gases.
eg. Water waves	eg. Sound waves.

Why transverse wave does not travel through air or gases?

Definitions

Amplitude (a): The maximum displacement of a particle from the mean position is called amplitude. Its unit is metre.

Time period (T) : Time taken by a particle of the medium to complete one vibration is called Time period. Its unit is second.

Frequency (n) : The number of vibrations completed by a particle in one second is called frequency . Its unit is hertz. $n = \frac{1}{T}$

Wave Length (λ) : Distance moved by a wave during the time a particle completes one vibration. Its unit is metre.

Velocity of a wave or Relation between Velocity, wavelength and Frequency

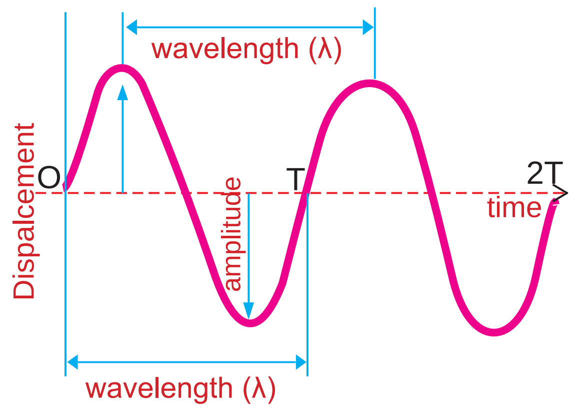
Distance travelled by a wave in T second = λ

$$\text{velocity} = \frac{\text{distance}}{\text{time}} = \frac{\lambda}{T}$$

but $n = \frac{1}{T}$

$\therefore$ $v = n\lambda$

Velocity = frequency x wavelength



MORE TO KNOW

Sound travels almost five times faster through water and twenty times faster through iron than it travels in air.

MORE TO KNOW

Speed of light (3×10^8 m/s) is much faster than the speed of sound (340 m/s). Light travels almost million times faster than sound. Due to this reason lightning flash is seen first and thunder sound is heard next.

17.4. REFLECTION OF SOUND

ACTIVITY –17.8

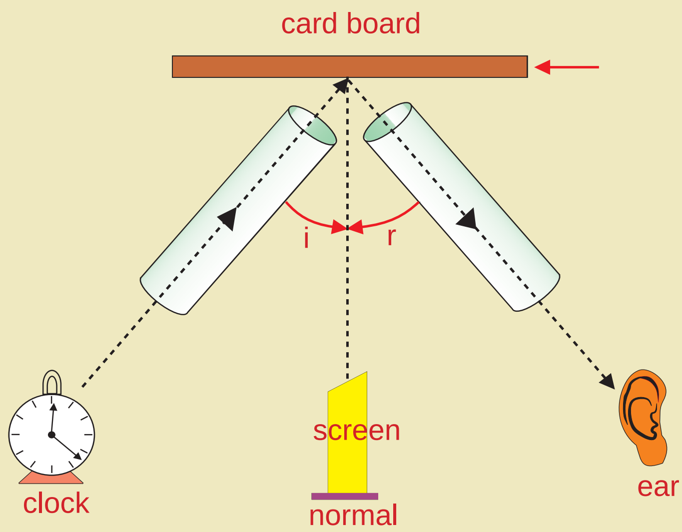
Take two identical pipes made of card board or chart paper or brown paper.

Arrange them on a table near a wall. Keep an alarm clock near the open end of one of the pipes and try to hear the sound of alarm clock through the other pipe as shown in fig.

Adjust the angles of pipes, so that you get maximum sound.

Realise that sound can also be reflected like light.

Sound can be reflected from hills and tall buildings.



17.4.1. ECHO

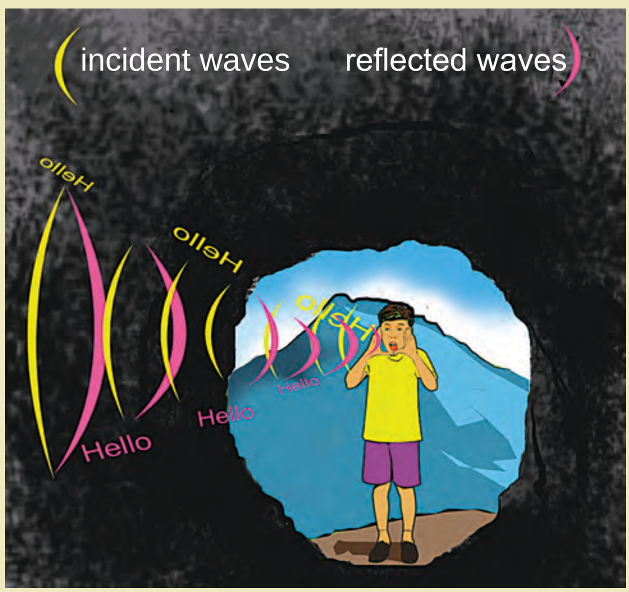
The sound waves produced by us bounce back or reflected from the forest or mountain or buildings come to our ears as Echo.

For example, the sound uttered by a person may be heard two or three times after the reflection from an object. They are called echo.

ACTIVITY –17.9

When you go to a cave or a subway and shout, you can hear the voice again, a short time after you have shouted.

The delay is caused by the time your voice has taken to travel to the walls and back again. You hear your voice as echo.



The sensation of sound persists in our brain for about 1/10th of a second. Any sound which comes as reflection to ear after 1/10th of second travels a distance of about 34 metre.

Therefore, to hear echo, the barrier reflecting the sound should be least at a distance of 17 meters. Why? Think!

$$\text{Velocity} = \frac{\text{distance}}{\text{time}}$$

$$\begin{aligned}\text{Distance} &= \text{velocity X time}\\ &= 340 \text{ X } 1/10\\ &= 34 \text{ m.}\end{aligned}$$

Echoes may be heard more than once due to successive or multiple reflections. The rolling of thunder is due to the successive reflections of the sound from a number of reflecting surfaces, such as cloud and land.

17.4.2. REVERBERATION

A sound created in a big hall will persist by repeated reflection from the walls until it is reduced to a value when it is no longer audible.

The repeated reflection that results in the persistence of sound is called reverberation.

Audio recording theatre

In an auditorium, big hall, theatres and audio recording theatres, etc, the excessive reverberation is highly undesirable. The reverberation time should not be more than its optimum value. For speech, it is 0.5 second, for music 1 to 1.5 second. To reduce reverberation, the roof and walls of auditorium are generally covered with sound absorbing materials like compressed fibre board, rough plaster or draperies. The seat materials are also selected on the basis of their sound absorbing properties.

17.5. RANGE OF HEARING

Sound is produced by vibrating bodies. We can hear sound of frequencies ranging from 20 Hz to 20,000 Hz. This range of frequencies, sensed by our ear is known as the audible range of sound for human beings. (One Hz= one cycle/second)

Sound of frequencies above 20,000 Hz are known as ultrasonic.

Sometimes sound produced by bats, dolphins are ultrasonic.

Sound of frequencies below 20Hz are called infrasonic.

We cannot hear ultrasonic and infrasonic. But certain animals can produce and detect ultrasonic and infrasonic.

Heinrich Rudolf Hertz (1857 - 94)

A German scientist, Hertz gave the first experimental proof of the existence of radio waves. He did research on the evaporation of liquids. He had a deep interest in meteorology also. The frequency which is measured in cycles / second was changed as hertz (Hz) after him.

Audible range of sound (in Hertz) for Human and certain animals

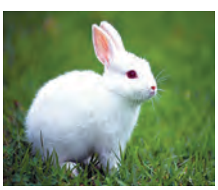

Human — 20 - 20,000


Elephant — 16 - 12,000


Cow — 16- 40,000


Cat — 100 - 32,000


Dog — 40 - 46,000


Rabbit — 1000 - 1,00,000


Bat — 1000 - 1,50,000


Dolphins — 70 -1,50,000


Seal — 900 – 2,00,000

ACTIVITY –17.10

Try to count different sounds you hear from various living beings from morning to night.

17.6. APPLICATION OF ULTRA SOUND

Ultra sound scan is currently considered to be a safe, non- invasive, accurate and cost effective investigation of the foetus. It has progressively become an indispensable obstetric tool and plays an important role in the care of every pregnant woman.

17.6.1. SONAR (SoundNavigationAnd Ranging)

Sonar is a device that uses ultrasonic waves to measure the distance, direction and speed of underwater objects and depth of the sea.

Sonar consists of a transmitter and a detector, installed in a ship as shown in fig 17.4.

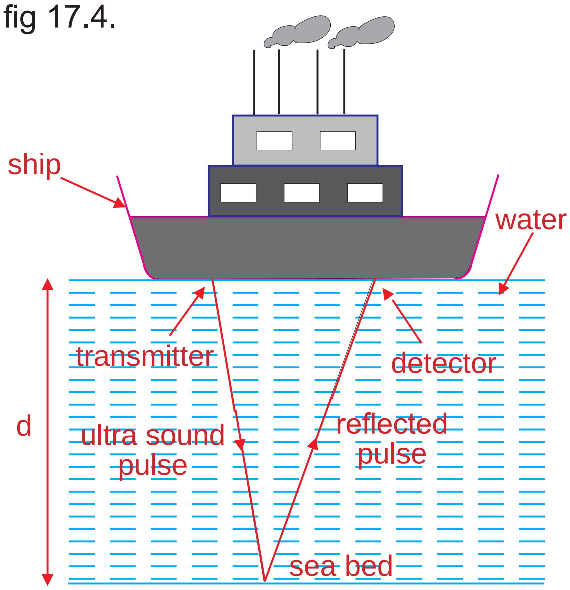


Fig 17.4. Ultra sound sent by transmitter and received by the detector

The transmitter produces and transmits ultrasonic waves. These waves travel through water and after striking the object on the sea bed, get reflected and are sensed by the detector. The detector converts the ultrasonic waves into electrical signal which are appropriately interpreted.

Echo Ranging

Set the time interval between transmission and reception of ultrasound is ‘t’ speed of sound through water is ‘v’ total distance travelled (to & fro) is ‘2d’.

$$2d = v \times t, \qquad d = \frac{v \times t}{2}$$

This method is called Echo Ranging. It is used to determine the depth of the sea and to locate under water hills, submarine, icebergs, sunken ship, etc.

ACTIVITY –17.11

Stand on a railway platform and hear the whistle sound of the train as it approaches and leaves.

17.6.2. DOPPLER EFFECT IN SOUND

The pitch of the whistle seems higher as the train comes towards you and lower when the train goes away from you.

If an observer is situated at a fixed distance from a sound source, the frequency of sound heard by him is the same as produced by the source.

But if the sound source or the observer or both are in a state of motion, the frequency of the sound appears to be changed to the observer.

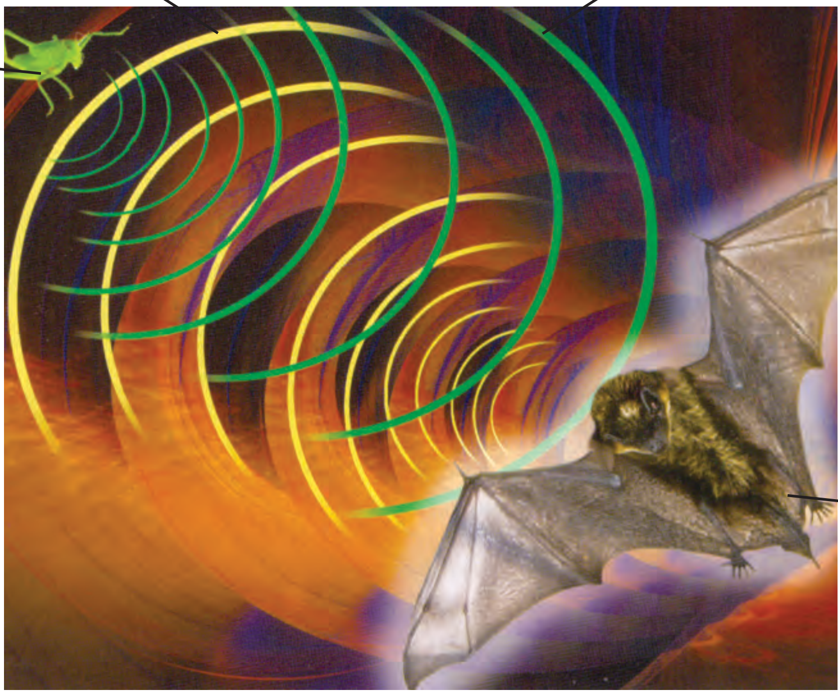
The phenomenon of the apparent change in the frequency of the source due to relative motion between the source and the observer is called as Doppler’s effect.

Christian Johann Doppler (1803 – 53)

He was an Austrian mathematician and physicist. He is known for his principle. He first proposed in concerning the coloured light of double stars in 1842. This principle is known as the Doppler effect. He hypothesized that the pitch of a sound would change if the source of the sound was moving. This principle is used in velocity and distance measurements and various applications.

Uses of Doppler effect in sound

- RADAR (Radio Detection And Ranging) Doppler effect principle is used in RADAR to determine the velocities and movement of submarines and aircrafts.
- Traffic control vehicles direct microwaves on speeding vehicles. The waves reflected by the moving vehicles act as a moving source. From the Doppler shift in frequency, the speed of vehicles are detected.
- The Doppler shift of radar waves are used in airports to find the height, speed and distance of approaching aircrafts.
- Bats send out and receive ultrasonic waves reflected by the prey and obstacles. Bats detect the location, distance and movement of the prey by the Doppler shift.



EVALUATION

Section – A

1. When we hear music, the medium through which the sound transmitted is __________. (solid, liquid, gas)

2. Pick the odd one out from the following intruments on basis of prodution of sound


Mouth organ

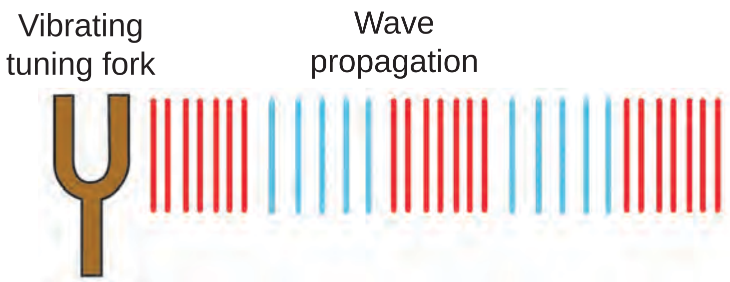

Veena


Flute

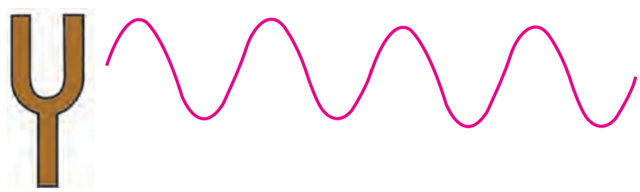

Clarinet

3. In the following diagram, state in which of the following cases, the sound propagates in air.

a)



b)



4. From the list of frequencies, find the ultrasonic frequency.

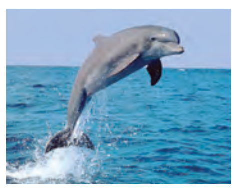
   (2000 Hz, 20000Hz, 30000 Hz, 10000 Hz)

5. The principle on which stethoscope works is _____ (reflection, multiple reflection)

6. Find the odd one out on the basis of audiable range


Elephant


Bat


Dolphin


Rabit

Section – B

7. Match the following

a) ripples on surface of water	longitudinal wave
b) light waves	electro magnetic transverse
c) sound waves	mechanical transverse

8. Two auditoriums, named A and B are constructed adjacently. The sound engineer examined both and gave report as follows

Auditorium	Reverberation time
A	1.5 s
B	0.5 s

Select the auditorium for,

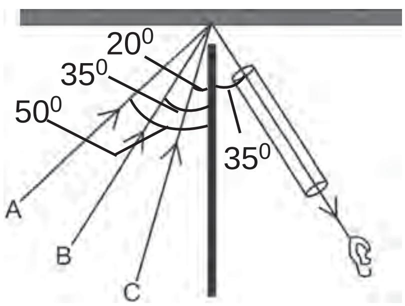
a) speech and seminar

b) cultural programmes

9. A sonar device on a submarine sends out a signal and receives an echo 5 s later. Calculate the speed of sound in water if the distance of the object from the submarine is 3625 m.

10. The echo of our sound is not heard in our living room, but it is heard distinctly in a big hall. Why?

11.



a) In which of the given position A, B or C, is an alarm clock to be placed, so that the maximum sound is heard by the observer.

b) Give reason for your answer.

12. In an auditorium or a cinema hall, the roof and walls are covered with draperies or compressed fibre board. Why?

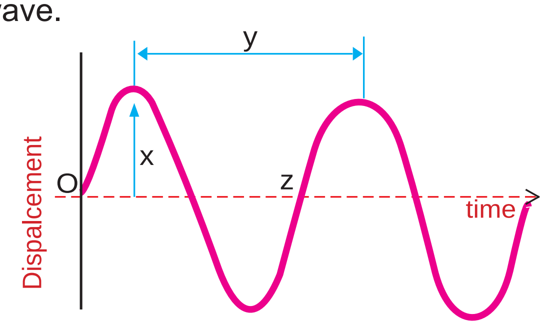
Section – C

13. The following figure represents a sound wave.

a) Draw and mark the name of the variables x, y and z.

b) Write the equation for velocity of a wave using the above variables.

c) Write any two differences between transverse and longitudinal waves.



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PRACTICALS

LIST OF PRACTICALS

S.No	Name of the Experiment	Aim of the Experiment	Apparatus/ Materials required	Time
1	Plant Cell	To prepare a temporary mount of the onion peel and study of plant cells	Onion bulb, watchglass, coverslip, slide, methylene blue or safrannin, glycerine, blotting paper and microscope	40 minute
2	Osmosis	To study the phenomenon of osmosis by using potato osmoscope	Potato, knife, sugar solution, beaker, coloured water, pins, etc.,	40 minute
3	Pollen Grain	To dust the pollen grains on the slide and observe under the dissection (simple) microscope. Draw and label the parts.	Flowers, dissection (simple) microscope, glass slide and needle	40 minute
4	Ascent of Sap	To prove the ascent of sap through xylem vessels by using balsam plant.	A bottle or a beaker, water, eosin stain or red ink and balsam plant	40 minute
5	Paramoecium	To identify the prepared slide of paramoceium	Compound microscope, paramoceium slide	40 minute
6	Purity of Milk	To measure the strength (purity of milk) by using lactometer.	Milk, lactometer	40 minute
7	Micro organisms	To identify the micro organisms in pond water	Pond water in a beaker, compound microscope, glass slide	40 minute
8	Ethyl Alcohol	To find out ethyl alcohol in a medium.	Ethyl alcohol, acidified potassium dichromate, test tube	40 minute

Sl. No	Name of the Experiment	Aim of the Experiment	Apparatus/ Materials required	Time
9	Measurement of volume of liquid	To measure the volumes of solutions using pipette	Pippette (20 ml) Beaker (250 ml)	40 Min.
10	Classification of Mixtures	To prepare different types of mixtures and classify them as homogeneous or heterogeneous	China dish, Beaker (100ml), Sugar, Glucose, Starch powder, Sodium Chloride, Copper Sulphate, Distilled water, Nickel spatula	40 Min.
11	Study the characteristics of metals	To determine the relative strengths (electropositive characters) of given metals	Test tube Lead , Zinc and Copper, $Pb(NO_3)_2$ $ZnSO_4$, $CuSO_4$	40 Min.
12	Identification of acid radicals in the given salt	To identify carbonate, chloride, sulphate acid radicals present in the given salt	Test tube Carbonate salt, Sulphate salt, Chloride salt, $BaCl_2$ $AgNO_3$, Dil. HCl,	40 Min.
13	Finding the diameter of a spherical body	To determine the diameter of a spherical body using vernier calipers.	Vernier calipers, Spherical body (Simple pendulum bob)	40 Min.
14	Finding the relation between length and time period of a simple pendulum	To find the period of oscillation and proving (l/T^2) is a constant	Simple pendulum apparatus (stand, bob, twine, split cork), stopwatch	40 Min.
15	Determining relative density of a solid	To determine the relative density of a solid heavier than water using Archimede's principle	Spring Balance, brass bob, beaker with water	40 Min.
16	Temperature – Time Relation	To determine the boiling point of water and to draw the cooling curve	Beaker with water, electric heater, tripod stand, wire gauze	40 Min.

1. TO STUDY A PLANT CELL

Aim:

To prepare a temporary slide of the onion peel and study of plant cells.

Materials Required:

An onion bulb, watchglass, coverslip, glass slide, methylene blue stain or safranin, glycerine, blotting paper and microscope.

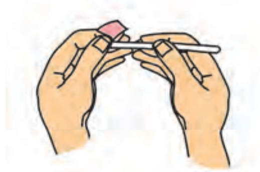
Procedure:

i. Cut a small piece of onion and separate a peel from one of its inner layers.
ii. Place the peel on a glass slide in a drop of water.
iii. Put a drop of methylene blue or safranin on the peel.
iv. Wash it in water to remove the excess stain.
v. Put a drop of glycerine and cover it with a coverslip
vi. Remove excess glycerine from the edges of coverslip with the help of a piece of blotting paper
vii. Observe the slide under the microscope first in low power and then in high power.

Observation:

Elongated and rectangular cells arranged in a brick like fashion, can be observed. Each cell has a rigid cell wall outside the plasma membrane and deeply coloured rounded nucleus surrounded by granular cytoplasm. The central part of the cell is occupied by the central vacuole.

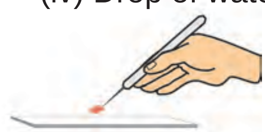
(i) Piece of onion bulb



(ii) Snap the scale backward

(iii) Pull the transparent peel steps to take out an onion peel

(iv) Drop of water



(v)

(vi) Stages to show the mounting procedure on a slide.

Draw a diagram of the cells as seen under microscope and label Nucleus, Vacuole and Cellwall.

2. TO STUDY THE PHENOMENON OF OSMOSIS

Aim:

To study the phenomenon of osmosis by potato osmoscope.

Principle:

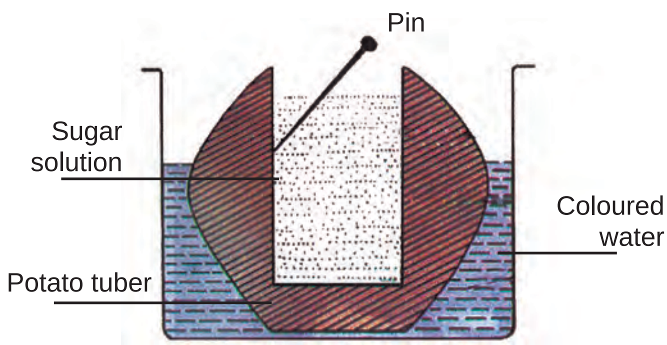
Movement of molecules of water or solvent from a region of its higher concentration to the region of its lower concentration through a semipermeable membrane is called osmosis.

Materials Required:

Potato, knife, sugar solution, beaker, coloured water, pins, etc,.

Procedure:

a. A potato is taken and peeled.
b. Its base is cut to make it flat.
c. A hollow cavity is made in the centre of the tuber filled with sugar solution.
d. The initial level of solution is marked with the help of a pin.
e. It is placed in a beaker containing coloured water.
f. Leave the experimental set up for sometime.
g. Final level of sugar solution is measured.



Record the observations in the table

Initial levl of sugar solution (mm)	Final level of sugar solution (mm)	Difference between initial level and final level (mm)

Inference:

The level of sugar solution ______ and becomes _______ due to ___________.

3. TO OBSERVE THE POLLEN GRAINS

Aim:

To dust the pollen grains on the slide and observe under the dissection (simple) microscope and draw and label the parts.

Materials Required:

Flowers, dissection (simple) microscope, glass slide and needle.

Procedure:

a. Collect the pollen grains from a given flower.
b. With the help of a needle, place the pollen grains on the slide.
c. Observe the slide under microscope.

Observation:

a. It is a single celled structure.
b. It has two layers. The outer exine which is spiny and the inner intine is thin and smooth.
c. It contains a single nucleus and cytoplasm.

Draw the structure of pollen grain as observed through microscope. Label Exine, Intine, Cytoplasm and Nucleus

4. TO PROVE ASCENT OF SAP

Aim:

To prove the ascent of sap through xylem vessels by using Balsam plant (Kasithumbai plant).

Principle:

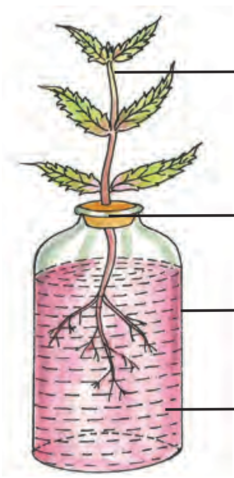
The conduction of water and mineral salts from the roots upward by the stem through the xylem vessels is known as the ascent of sap.

Materials Required:

A bottle, water, eosin stain or red ink and Balsam plant.

Procedure:

a) Take a bottle containing water and add a few drops of eosin stain or red ink.
b) Close the mouth of the bottle with a one-holed rubber cork.
c) Insert a balsam plant into it.
d) Keep the apparatus undisturbed for some time.



Record the periodical observations in the interval of 10 minute each.

Sl.No	Periodicity	Observations
1.	After 10 Minute	
2.	After 20 Minute	
3.	After 30 Minute	

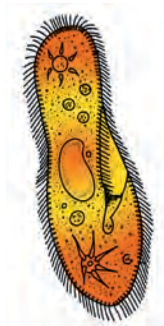
Inference:

Red streaks seen in the stem and in the veins of leaves prove that ....
....

5. TO IDENTIFY PARAMOECIUM

Observe a prepared slide of paramoecium under a compound microscope. Draw and label the parts.

Preparation of sample



Take few pieces of straw and immerse inside a beaker containing water and keep it for about 3 days.

Number of paramoecium are developed, while the straw is decaying.

Place a drop of water on the slide from the beaker and observe it under compound microscope.

Identification:

The slide kept for identification is an unicellular protozoan – the paramoecium.

Observation:

1. Structure of paramoecium
2. Locomotion of paramoecium

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6. TO FIND OUT THE PURITY OF MILK

Aim:

To find out the strength (purity) of milk by using a lactometer.

Requirement:

Milk, lactometer.

Principle:

100ml of pure milk is taken in a beaker. The meter bulb is dipped into the beaker. The bulb just sinks and then begin to float. The reading on the meter ________ indicates the purity of milk.

Observation:

If the bulb sinks deeper, it indicates that the milk contains more water and if the reading is at mark, it shows that the milk is very rich and pure.

Sl.No	Milk	Water	Lactometer reading
1	100 ml	Nil	
2	100 ml	10ml	
3	100 ml	20ml	
4	100 ml	30ml	

Result:

Thus the lactometer is used to find out the strength (purity) of the milk.

7. TO DETECT MICRO ORGANISMS IN POND WATER

Aim:

To identify various microorganisms (any three) seen in a drop of pond water. Draw diagram.

Requirements:

A glass beaker with pond water, glass slide, compound microscope.

Procedure:

A drop of pond water is kept on a glass slide. The slide is kept under the microscope.

Observation:

Any three micro organisms in the pond water may be identified and neat diagrams are drawn.

Result:

The organisms found in pond water are

Name
1. Diagram

Name
2. Diagram

Name
3. Diagram

8. TO FIND OUT ETHYL ALCOHOL IN THE MEDIUM

Aim:

To find out ethyl alcohol in the medium.

Required Materials:

Ethyl alcohol, acidified potassium dichromate

Procedure:

Take 5 ml of acidified potassium dichromate in a test tube. Add a drop of ethyl alcohol and shake well. Slowly the colour of the mixture red orange is turned into green. It shows the presence of alcohol.

Inference:

In this reaction chromium ions (Cr VI) red orange is converted into (Cr III), which is green in colour.

Experiment	Observation	Inference
Acidified potassium dichromate is treated with a drop of ethyl alcohol	.... colour of the mixture is turned into	presence of ....

Result:

The presence of .... is confirmed / not confirmed.

Importance of this test:

This test is used to find out a drunkard. It is a respiratory analysis.

9. TO MEASURE VOLUME OF LIQUIDS

Aim:

To measure the volumes of given colourless and coloured solutions using pipette.

Required Materials:

Pipette (20 ml), beaker (250 ml).

Procedure:

Take a pipette of definite volume. Wash it with water and then rinse with the given solution. Put the lower end of the pipette well below the surface of the liquid and suck the solution slowly, till the solution rises well above the circular mark on the stem. Take it out of your mouth and quickly close it with the fore finger. Raise the pipette till the circular mark is at level with your eye. Then release the pressure of your finger slightly to let the liquid drop out slowly until the lower part of the meniscus just touches the circular mark (For coloured solutions, upper meniscus should be taken into account.) To discharge, introduce the lower end of the pipette inside the receiving vessel and remove the finger. Record the volume of liquid measured in the tabular column.

Tabulation:

Sl No.	Name of Liquid	Nature of colour	Nature of meniscus	Volume of liquid

Report:

The volume of liquid measured using pipette is _______________ ml.

Precaution:

Never use a pipette for sucking strong acids or strong alkalies.

10. CLASSIFICATION OF MIXTURES

Aim:

To prepare different types of mixtures and classify them as homogeneous or heterogeneous.

Required Materials:

China dish, Beaker (100ml), Sugar, Glucose, Starch powder, Sodium Chloride, Copper Sulphate, Distilled water, Nickel spatula.

Principle:

Homogeneous mixtures have only one phase and have the same properties throughout the sample.

Heterogeneous mixtures have more than one phase and do not have the same properties throughout the sample.

Procedure:

Take 2g each of sugar and sodium chloride in a china dish. Mix them thoroughly using a Nickel spatula. After mixing, observe the mixture. Is there any change in the appearance? Identify the nature of mixture.

Take 50ml of water in a 100ml beaker. Add sodium chloride and copper sulphate salts into it. Stir the mixture well and identify the nature of mixture.

Record your observations in the tabular column using the following mixtures and classify them whether homogeneous or heterogeneous.

Tabulation:

Sl. No.	Components of the mixture	Type of mixture

Report:

The given mixture is identified as ________________ mixture.

11. TO STUDY THE CHARACTERISTICS OF METALS

Aim:

To determine the relative strengths (electropositive characters) of given metals.

Principle:

Relative strengths of metals can be determined by the precipitation of one metal by another.

Chemicals required:

- Small pieces of ***copper***, ***lead*** and ***zinc***
- Solutions of ***leadnitrate***, ***coppersulphate*** and ***zincsulphate.***

Procedure:

Trial 1: Take about 5ml each of ***leadnitrate*** and ***zincsulphate*** in two separate test tubes. Add pieces of ***copper*** to both the tubes and observe the changes and record. (No chemical change occurs in both the tubes).

Tabulation:

Sl. No.	Solutions taken	Metal added	Observation

Trial 2 : Take about 5ml each of ***coppersulphate*** and ***zincsulphate*** solutions in two separate test tubes. Add pieces of ***lead*** to both the tubes and observe the changes (lead reacts with copper sulphate and not with zinc sulphate).

Tabulation:

Sl. No.	Solutions taken	Metal added	Observation

Trial 3 : Take about 5ml of ***coppersulphate*** and ***leadnitrate*** solutions in two separate test tubes. Add pieces of ***zinc*** to both the tubes and observe the changes (Zinc reacts with both copper sulphate and lead nitrate).

Tabulation:

Sl. No.	Solutions taken	Metal added	Observation

Report:

The order of relative strengths of the metals are____ >____ >____.

12. TO IDENTIFY ACID RADICALS

Aim:

To identify the acid radical present in the given salt.

Identification of Carbonate acid radical

Experiment	Observation
1. Take about 1g of the salt in a test tube. Add 2-3ml of **dilute hydrochloric acid**.	**Brisk effervescence** due to the liberation of $\mathbf{CO_2}$ gas.
2. To the salt solution, add few drops of **Magnesium sulphate** solution.	A **white** precipitate of **magnesium carbonate** is formed.

Report: The acid radical present in the salt is ______________________________.

Identification of Chloride acid radical

Experiment	Observation
1. Take about 1g of the given salt in test tube.To which add very little amount of **manganesedioxide** followed by **conc.sulphuric acid**. Heat the mixture for few seconds.	Evolution of **greenish yellow chlorine** gas (Cl_2).
2. Add few drops of **silver nitrate** solution to the aqueous solution of the salt.	A **curdy white** precipitate of **silver chloride** is formed.

Report: The acid radical present in the salt is ______________________________.

Identification of Sulphate acid radical

Experiment	Observation
1. Take a pinch of the salt in a test tube. Add water. If the salt is insoluble in water add **dil.hydrochloric acid** till the effervescence ceases. Then add **Barium chloride** solution.	Formation of a **white precipitate** of Barium sulphate.
2. Add a few drops of **lead acetate** solution to the aqueous solution of the salt.	Formation of a **white precipitate** of Lead sulphate.

Report: The acid radical present in the salt is ______________________________.

13. FINDING THE DIAMETER OF A SPHERICAL BODY

Aim:

To determine the diameter of a spherical body using Vernier Calipers.

Apparatus required:

The Vernier calipers, the given spherical body

Formula:

Diameter of the sphere = OR ± ZC x 10^{-2} m

OR = MSR +(VC x LC) x 10^{-2} m

Where, OR = Observed Reading x 10^{-2} m

MSR = Main scale reading x 10^{-2} m

LC = Least count x 10^{-2} m

VC = Vernier coincidence

ZC = Zero correction x 10^{-2} m

Procedure:

- Find the Least Count of the Vernier Calipers.
- Find also the Zero Error of the Vernier Calipers.
- Place the body firmly between the two lower jaws.
- Note the main scale reading and the Vernier coincidence.
- Repeat the experiment for different positions of the body.
- Measure the diameter of the sphere using the formula,

Diameter of the sphere = OR ± ZC, OR = MSR +(VC x LC)

Observation:

Number of Vernier scale divisions, N =

Value of one main scale division(1MSD) =

$$\text{Least Count} = \frac{1}{N} \times 1\text{MSD}$$

ZE = ZC =

S.No	Main Scale Reading (MSR) cm	Vernier Coincidence (VC)	Observed Reading (OR) = MSR+(VC x LC) cm	Corrected Reading OR±ZC cm
1				
2				
3				
4				
			Mean	

Diameter of the sphere =

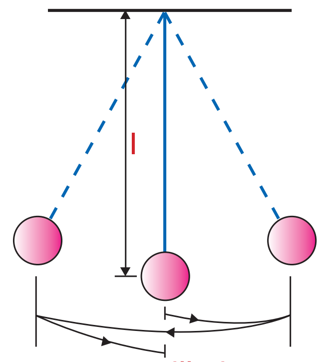
Result :

Diameter of the given sphere = x 10^{-2}m

14. FINDING THE RELATION BETWEEN LENGTH AND TIME PERIOD OF SIMPLE PENDULUM

Aim:

To find the period of oscillation of a simple pendulum and to prove that l/T^2 is a constant.



Apparatus required:

Simple pendulum apparatus, stop watch.

Formula:

l/T^2 is a constant

Where, l is the length of the simple pendulum (m)

T is the Period of oscillation of the simple pendulum (s)

Procedure:

- Suspend the simple pendulum for a length of 70 cm.
- Make the pendulum to oscillate with small amplitude.
- When the pendulum crosses the mean position towards the right, start a stop watch and count zero.
- When it crosses the mean position towards the right next time, count one.
- Like this count up to twenty and stop the stopwatch.
- Find the time taken for 20 oscillations and record in the tabulation.
- Repeat the experiment by changing the length to 80cm, 90cm, 100cm and 110cm.
- Tabulate the readings and find T, T^2 & l/T^2.
- The last column of the tabulation is found to be constant, hence proving l/T^2 is a constant.

Observation:

S. No.	Length of the simple pendulum m	Time taken for 20 oscillations s	Period T s	T^2 s^2	l/T^2 m s^{-2}
1	0.7				
2	0.8				
3	0.9				
4	1.0				
5	1.1				

Result:

From the table, it is found that l/T^2 is a constant.

15. DETERMINING RELATIVE DENSITY OF A SOLID

Aim:

To determine the relative density of a solid heavier than water using Archimedes' principle.

Apparatus required:

Spring balance, three spherical bodies of same material but different weight (e.g. 3 brass simple pendulum bobs of different size), beaker with water.

Formula:

$$R.D = \frac{w_1}{w_1 - w_2} \quad \text{no unit}$$

where,

R.D = relative density of the solid (kg m^{-3})
w_1 = weight of the solid in air (kg)
w_2 = weight of the solid in water (kg)

Procedure:

- Suspend the given solid from the hook of a spring balance.
- Find the weight of the solid in air (w_1).
- Immerse the solid in a beaker of water.
- Find the weight of the solid in water (w_2).
- Find the weight of the other two solids in air and water.
- Enter the readings in a tabular column.
- Take the average of the last column reading as the relative density of the given solid.

Observation:

S. No.	Weight of the solid in air x 10^{-3} kg w_1	Weight of the solid in water x 10^{-3} kg w_2	$R.D = \frac{w_1}{w_1 - w_2}$ no unit

Mean ____________

Result:

Relative density of the given solid = __________ no unit

Note:

(i) The body should be completely immersed in water
(ii) The body should not touch the sides or bottom of the beaker
(iii) No air bubbles sticking to the solid

16. TEMPERATURE – TIME RELATIONSHIP

Aim:

To determine the boiling point of water and to draw the cooling curve.

Apparatus required:

Beaker with water, electric heater, tripod stand, wire gauze, graph sheet, thermometer.

Procedure:

- Place the beaker with water over the wire gauze placed on the tripod stand.
- Fix a thermometer to a stand and immerse it in water.
- Heat the beaker with a electric heater.
- When water boils, note the thermometer reading.
- It gives the boiling point of water.
- Stop heating and allow water to cool.
- Take the thermometer reading while switching on the stop clock.
- Find temperature interval using stop clock.
- Similarly note the thermometer reading for every one minute interval till the temperature falls upto 60^oc.
- Record the readings in the tabulation.

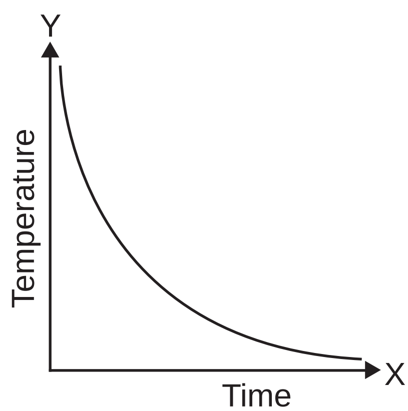
Observation:

Maximum temperature measured = ____ ^oc

The boiling point of water = ____ ^oc

Time (minute)	Temperature (^oc)
0	
1	
2	
3	
4	
5	
6	
7	

For a suitable scale draw the cooling curve by taking time along the x axis and temperature along the y axis.



Result:

1. The boiling point of water = ____ ^oc
2. The cooling curve is drawn