

Science Notes Part 56 to 60

56] Addiction And Healthy Lifestyle

ADDICTION

Addiction is a complex disease that affects the brain. When a person who is weak-willed or vulnerable is exposed to large amounts of stress, he or she consume substances or looks for methods that create a feeling of immediate relief. It can be abuse or misuse of substance like consuming alcohol or drugs; or behavioural problems such as gambling, video games, and excessive work, food, and sex. These

substances or activities can alter the way we think or the way brain functions. Continued and indiscriminate use of these substances over a period of time creates addiction.

The term 'addiction' is used to describe a compulsion by an individual to engage obsessively in some specific activity. Addiction leads to harmful consequences to an individual's health, mental state and social life.

This typically happens when drugs and alcohol are misused and consumed in large quantities without the consultation of medical practitioners. They affect the central nervous system, liver, spleen, kidney and heart and the individual eventually suffers from addiction.

Addiction is a chronic disease and can relapse (come back again) after a period of time. It affects the brain's responses and motivation systems. People struggling with addiction will be unable to control their actions or make sensible decisions about their behaviour, even if the consequences are negative or dangerous.

There are several reasons for addiction, both personal and social. Some become addicts due to personal trauma or emotional disturbances. Others become addicts due to peer pressure and unregulated habits.

Addiction can be due to any of these two ways of dependence:

Substance-related Addiction: This includes dependence on any of the following:

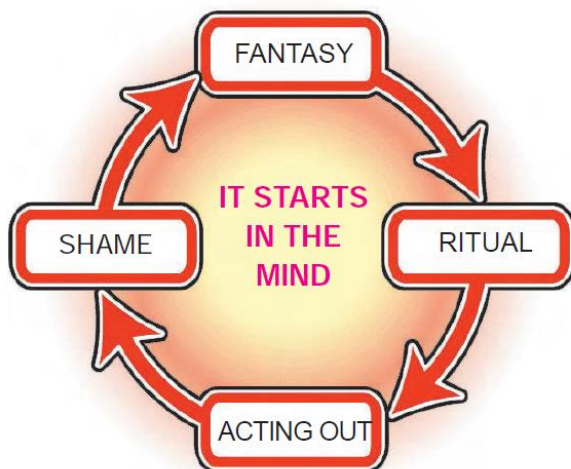
- Tobacco
- Alcohol
- Street drugs (illegally sold drugs that are taken for non-medicinal use. e.g. LSD, amphetamines)
- Prescription drugs (medicinal drugs that are misused. e.g. sleeping pills and pain-killers)

Behaviour-related Addiction: This may be due to excessive indulgence in the following activities:

- Gambling
- Eating
- the Internet
- Video Games
- Work
- Sex

ALCOHOLISM

Alcoholism is also known as alcohol dependence. Alcoholics suffer from an uncontrollable desire to consume alcohol individuals, it starts as social drinking that eventually leads to heavier and heavier alcohol consumption, and later causes serious health and psychological problems.

The Addiction Cycle

Ethyl alcohol (C_2H_5OH) or ethanol, is an intoxicating ingredient found in beer, wine and liquor. Alcohol is produced by the fermentation of yeast, sugar and starch. It is a depressant that affects the central nervous system.

Some of the symptoms of alcoholism:

Drinking alone, drinking in secret, blacking out - not being able to remember the passage time, being annoyed when not able to drink, having alcohol hidden in unlikely places, gulping drinks down in order to drink more and then feel good, needing a larger quantity of alcohol to feel its effect, feeling nausea, sweating, or even shaking when not drinking.

The problems linked to alcohol dependence are extensive and affect the person physically, psychologically and socially.

Psychologically it could cause mental illness, depression and suicidal tendencies. This could result in behavioural problems in their social life resulting in work abuse, child abuse, spouse beating, fights with neighbours and vulnerability to accidents.

Every year, there are about 27,000 deaths all over the world because of liver cirrhosis. Alcohol-related cirrhosis leads to more death than cirrhosis due to any other cause.

Physically it could lead to fatigue, memory loss, weakening of eye muscles, gastritis, pancreas damage, hypertension, heart failure, stroke, diabetes, cancer and liver cirrhosis.

Liver Cirrhosis

One of the reasons for liver cirrhosis is alcoholism. It starts with inflammation of the liver. Over a period of time it leads to scarring of the liver tissue and finally cirrhosis of the liver. A healthy liver is able to regenerate most of its own cells when they become damaged. At the final stage of cirrhosis, the liver can no longer effectively replace damaged cells.

Prevention and treatment of alcoholism

Addiction to alcohol can be prevented at an early stage by taking the following steps:

- The harmful effects of alcohol must be explained to people.
- If the addiction has developed due to being idle or by the pressure of the job, both the idleness and the nature of the job should be changed.
- Psychotherapy helps the patients in changing their lifestyle.
- By educating parents and teachers how to help the patients recover from alcoholic addiction.
- Drug therapy is also a valuable treatment. Medicines like Benzodiazepines, high dose of vitamin B and antidepressants like phenothiazines are effective in the recovery of alcoholic addiction.
- A number of voluntary organizations are financially assisting to undertake the educative work in various communities and target groups.

SMOKING CIGARETTES

Nicotine is one of the most frequently used addictive drugs and the leading preventable cause of disease and disability and death in India. Cigarettes and tobacco in any form are illegal substance in most countries.

EFFECT ON LUNGS : Smoking destroys the small hairs (cilia) present in the upper respiratory tract (trachea). In normal persons these hairs protect lungs from germs, dust, smoke and other harmful chemicals which enter the lungs causing infection, cough and lung cancer. The air sacs of lungs (alveoli) get permanently damaged causing difficulty in breathing.

EFFECT ON THE DIGESTIVE SYSTEM:

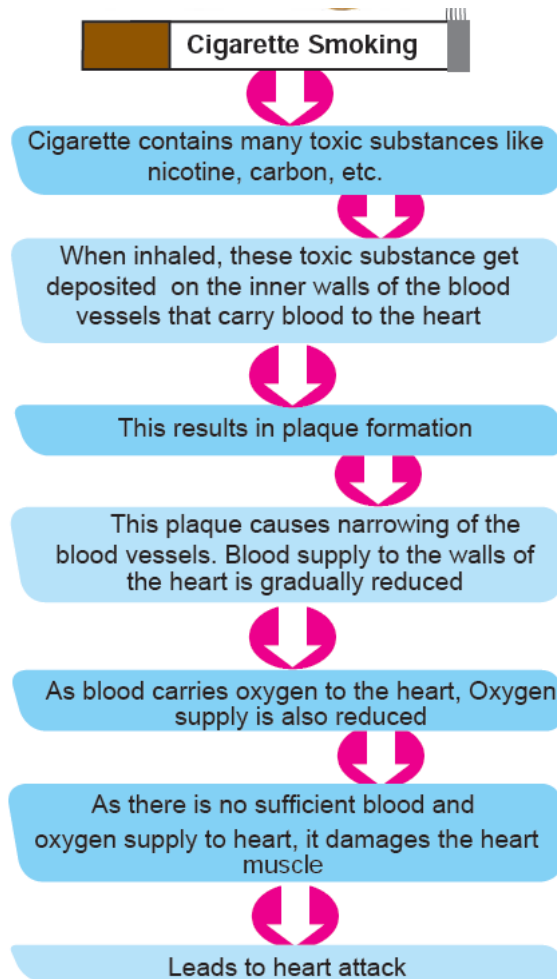
Smoking causes heart burn, delays the healing of peptic ulcer, increases risk of Crohn's diseases and formation of gall stones. It affects the liver and increases the chances of stomach cancer.

OTHER EFFECTS OF SMOKING

LEGS : Smoking affects the blood vessels of the legs causing chronic pain in legs.

EYES : The sensitive blood vessels of the eyes are easily damaged by smoking. This causes redness of eyes and itching. Heavy smoking may lead to degeneration and loss of eye sight.

EFFECTS OF SMOKING ON HEART



Smoking causes diseases like heart attack, hypertension (high blood pressure), cardio– vascular diseases and finally leads to death

SKIN : Due to smoking, the skin is deprived of oxygen and it loses its texture. An average smoker looks five years older than his healthy non-smoking counterparts. The skin loses its healthy glow and takes on a yellowish-grey cast. The more cigarettes one smokes, the worse the skin will look. Wrinkles start appearing very quickly as smoking affects the elastic nature of the tissues of the skin.

BONES : It accelerates the process of osteoporosis.

CANCER

Smoking causes cancer in lungs, larynx, oral cavity, pharynx, oesophagus and bladder.

Tobacco smoke contains more than 60 substances that could cause cancer. Most of the lung cancer occurs due to smoking.

EFFECT ON THE REPRODUCTIVE SYSTEM

Smoking reduces fertility in both men and women.

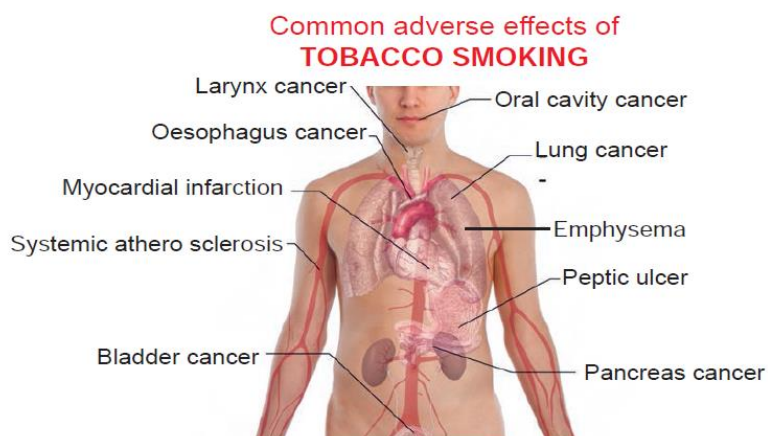
In women : Smoking creates an imbalance in estrogen hormone in women and reduces bloodflow to genital organs. Women who smoke can develop diseases in the fallopian tubes and their egg production can be affected. Smoking can cause abortion. It accelerates the ageing process and can cause early menopause.

Growth can suffer retardation when a mother smokes during pregnancy. It affects the brain development of the baby and reduces the IQ. This happens even when the mother is a passive smoker. The chances of miscarriage, premature birth and foetal death also increases.

In men: Smoking causes damages to the male reproductive system in many ways. Men who smoke have a higher risk of developing impotency.

2.1.3. DRUG ABUSE - NARCOTIC DRUGS

A drug or other substance affecting mood or behaviour and sold for non-medical purposes are called illegal drugs or narcotics. Consumption of such drugs over a long period of time have a direct effect on the central nervous system and its related problems. Heroin, opium, cocaine are some examples of narcotic drugs.



Harmful effects of drug abuse include:

impaired health, absence from school and college, and tendency to commit crimes like theft, rape or murder.

Signs of drug abuse

- Sudden change of mood and temper.
- Bouts of drowsiness or sleeplessness.

- Body pain, nausea, unsteady gait.
- Losing interest in job and studies.
- Telling lies and stealing money.

Dealing in Narcotic is an offence and all these come under punishable acts

- Possession even in a small quantity.
- Cultivation of drug crops without permission.
- Allowing your premises to store, sell or consumption.
- Illicit manufacture, sale, purchase and transportation.
- Trafficking of drugs is a non-bailable offence (Prison sentence up to 20 years and fine up to Rs.2 lakhs)
- Death penalty for repeat offenders.

What we should do as students:

- Always resist peer pressure and “Say No to Drugs “
- Drugs are not “cool”. Decide for yourself.
- Girl students should be cautious of taking drinks containing “date rape drugs”.
- Report drug abuse or trafficking to your school or college authorities or police.

TREATMENT OF ADDICTION

It involves the management of alcoholism and drug abuse. There are Governmental and non-governmental organizations in our country which have rehabilitation centres to treat and counsel drug addicts and alcoholics by means of medical and psychological approaches. The following are some of the steps taken in a rehabilitation centre.

First step	The identification of addicted individuals.
Second step	The composition of the drug is analyzed.
Third step	The addicted individual is studied to find out whether the dependency is physical or psychological.
Fourth step	A suitable chemotherapy is given to the addicts to detoxify the drug consumed.
Fifth step	Treatment should be given for a long time.
Sixth step	There should be periodical observation given according to his/her physical, mental, social and occupational status.

HEALTHY LIFESTYLE

“Healthy lifestyle” is a term given to a group of habits like healthy eating, being physically active, leading a smoke-free and stress-free life. India is predicted to become the diabetic and cardio-vascular disease capital of the world.

Obesity

Addiction to rich food can lead to obesity. It is defined as an excessive accumulation of fat in the body. It will to increased health problems. Lethargy, sluggishness and difficulty in carrying out the activities of

daily living are some of the adverse effects of obesity. The causes of obesity are unhealthy dietary habits, lack of physical activity, genetic susceptibility, endocrine disorders and some medicines.

Prevention of Obesity

In order to avoid obesity, we can make dietary and lifestyle changes, some of which are listed below:

- Eat plenty of food rich in fibre such as fruits and green leafy vegetables. Intake of steamed and oil-free foods like idli, idiyappam and puttu is recommended.
- Nuts, whole grains, seasonal fruits and vegetables can be consumed.
- Eating fish twice a week helps to prevent formation of blood clots in arteries, as it contains Omega-3 fatty acids.
- Eat less red meat (mutton, beef) and fried foods (chips, samosas) because they raise the blood cholesterol level.
- Milk and milk products (ghee, butter, cheese) are a good source of calcium, but excessive amount of creamy, fatty milk leads to obesity.
- Avoid high calorie fast foods like pizzas, burgers and French fries.
- Reduce dietary sugars (sweets, sugary drinks, chocolates) and salt (pickles, pappads) in the diet.
- Cigarette smoking and alcohol consumption should be avoided.

Physical Activities

- Reduce or limit the time of watching television, using computer and playing video games.
- Increase physical activity to burn calories which in turn enhances optimal blood circulation.e.g. Walking for an hour every day, playing outdoor games, jogging, running, cycling, swimming or dancing.
- Aim for ideal weight by following appropriate dietary habits and adequate physical activity.

Stress Relieving Activities

The following activities can relieve us from stress. Share your feelings with family and friends, manage your time, get enough sleep, spend time with nature, listen to music, engage in gardening, painting, playing with pets or going out for picnics with family, or any activity that helps you to relax.

57] Pollution And Ozone Depletion

POLLUTION AND OZONE DEPLETION

The atmosphere is a layer of gases which surrounds the entire Earth. It consists mainly of Nitrogen, Oxygen, as well as a few other gaseous elements. The purpose of this layer around the Earth is to prevent excessive amounts of radiation from reaching the Earth, thereby allowing us to survive. When a contaminant is introduced into the atmosphere it causes pollution. This has a direct impact on living conditions.

Pollution is an undesirable change in the physical, chemical and biological characteristics of our land, air or water caused by excessive accumulation of pollutants.

3.1. KINDS OF POLLUTION

Pollution is of four major types, namely air pollution, water pollution, land pollution and noise pollution. In terms of origin, it may be natural or anthropogenic (manmade). Degradation of air quality and natural atmospheric condition constitutes air pollution. The air pollutant may be a gas or particulate matter.

3.1.1. AIR POLLUTANTS AND THEIR EFFECTS

- 1. Particulate matter :** Exhaust gas from vehicles and smoke from industries contain small suspended particles such as soot, dust, pesticides and biological agents such as spores, pollen and dust mites. It causes respiratory ailments such as asthma, emphysema and chronic bronchitis.
- 2. Carbon-monoxide :** It is a product of incomplete combustion of fossil fuels in automobiles. It is highly poisonous to animals and humans. When inhaled, carbon monoxide reduces the oxygen-carrying capacity of blood.
- 3. Hydrocarbons :** Hydrocarbons such as methane are evolved from soil microbes (methanogens) in flooded rice fields and swamps. They are also generated during the burning of coal and petroleum products.
- 4. Sulphur dioxide :** It is released from oil refineries and ore smelters which use sulphur-containing fuels. The sulphur dioxide that is released into the air dissolves in rain water and forms an acid causing acid rain. This acid rain has harmful effects on plants and animals. It causes chlorosis (loss of chlorophyll) and necrosis (localised death of tissues) in plants. It also has a corrosive effect on limestone and mortar structures.
- 5. Nitrogen oxides :** These are also caused from the emissions of vehicles. These gases cause a reddish-brown haze (brown air) in polluted air caused by traffic congestion which contributes to heart and lung problems. It also contributes to the formation of acid rain.

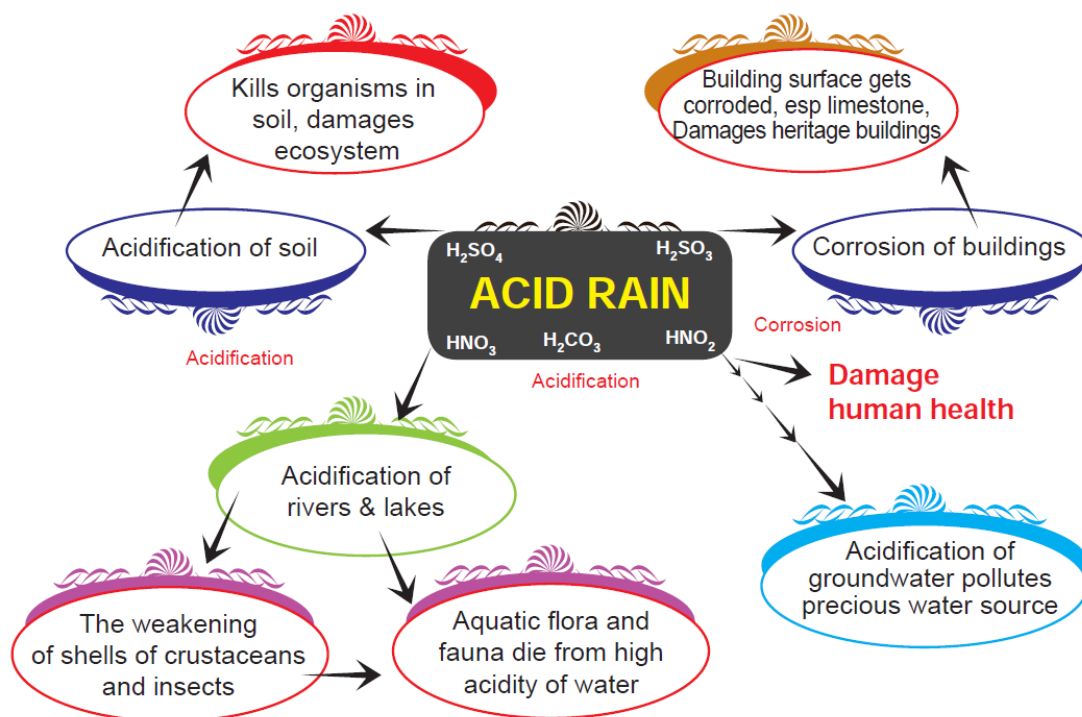
Secondary Effects of Air Pollution

Photochemical Smog

Smog is a mixture of smoke and fog. It is formed in the atmosphere under the influence of sunlight by the photochemical reactions of hydrocarbons, oxides of nitrogen and oxygen, resulting in the formation of PAN (peroxy acetyl nitrate). PAN damages chlorophyll and affects photosynthesis and growth. It also causes irritation of eyes and throat. Visibility is reduced due to smog.

Acid Rain

Gases such as sulphur dioxide and nitrogen oxides are oxidized to form sulphuric and nitric acid along with water, and precipitate as acid rain. It damages building, plants and animals. It also makes the soil acidic.



Control of Air Pollution

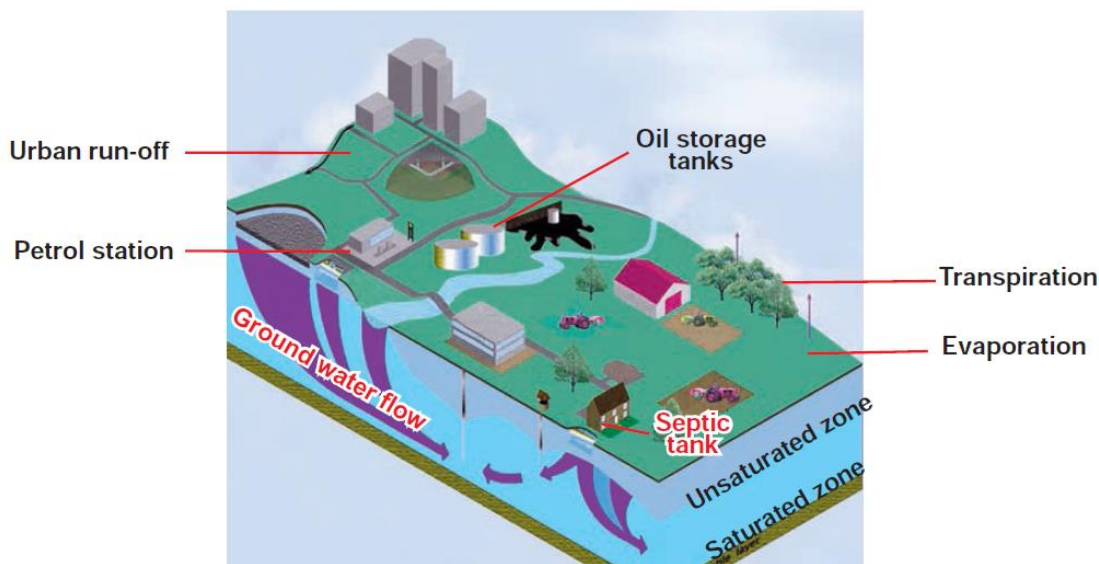
1. The particulates emitted by industries should be controlled by devices such as scrubbers, precipitators and filters.
2. Use of unleaded or low sulphur fuel is to be encouraged.
3. Shifting to non-conventional sources of energy (e.g solar energy, hydel energy, tidal energy, etc.) in order to reduce the dependance on conventional sources.
4. Smoking in public places should be prohibited, because cigarette smoke contains carcinogens such as benzopyrene. It also affects nonsmokers. (ie. Passive smoker)
5. Planting of trees along road sides and around industrial areas will reduce pollutants in the air. It will enrich the air with oxygen.

Black Lung disease

It is common among coal miners due to the inhalation of carbon particulates which leads to lung cancer.

3.1.2. WATER POLLUTION

Human activity creates several pollutants that contaminate water. Water pollution is defined as the adding of unwanted substances or the change of physical and chemical characteristics of water in any way which makes it unfit for human consumption. It is caused by waste products from industries (effluents), domestic sewage, oil spillage, agricultural and industrial run-offs. Sources and Effects of Water Pollution



1. **Industrial Wastes** : Industrial effluents containing heavy metals and chemicals such as arsenic, cadmium, copper, chromium, mercury, zinc and nickel are directly released into water bodies such as lakes, ponds and rivers without proper treatment. These wastes contaminate the water bodies and make them unsuitable for human consumption. Industries also use water as a coolant for machinery and releases hot waste water into the water bodies causing thermal pollution which affect both plant and animal life.

BHOPAL GAS TRAGEDY (2nd & 3rd Dec 1984) refers to the industrial disaster which killed thousands of people and animals due to inhaling of methyl iso cyanate (MIC) gas which leaked out from a fertilizer factory owned by the Union Carbide Company. Many people who inhaled the gas still suffer from respiratory, immunological and neurological disorders, cardiac failure, birth defects, etc.

2. **The Surface Run-offs** : The water that runs off the surface come from agricultural lands that are contaminated with pesticides and the residue of inorganic fertilizers rich in organic and inorganic compounds. These pollutants contaminate both surface and groundwater.
3. **Oil Spills** : An oil spill is an accidental discharge of petroleum products into oceans and estuaries from capsized oil tankers, offshore drilling and exploration operations. It can cause drastic damage to marine and coastal biodiversity.
4. **Domestic Sewage** : It is rich in organic matter and detergents. Decomposition of organic matter increases the nutrient content of the water bodies.

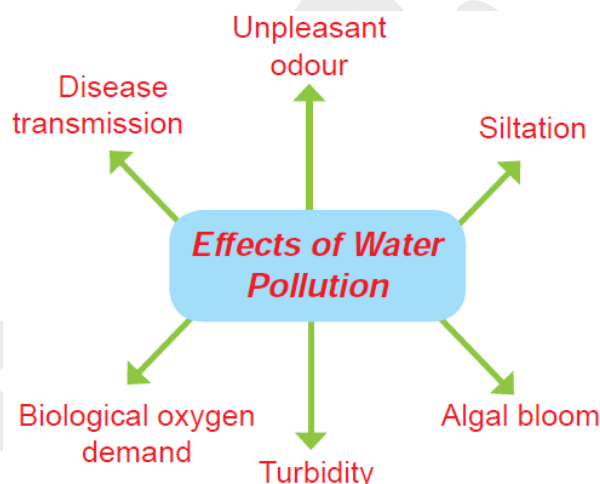
Availability of excess nutrients results in algal bloom on the surface of water resulting in the deficiency of oxygen content. This oxygen shortage leads to the death of aquatic organisms. This process is known as eutrophication.

Control of Water Pollution

1. Sewage treatment plants should be installed to treat sewage before releasing it into water bodies.
2. Excessive use of pesticides, herbicides and fertilizers should be avoided.
3. Biological control of insect pests and organic farming is to be followed in order to reduce the dependence on pesticides and inorganic fertilizers.
4. Control pollution through legislation and strict enforcement.
5. Create social awareness among people about water pollution and the need for pure water.

MINAMATA DISEASE

Mercury poisoning due to the consumption of fish captured from mercury contaminated Minamata Bay in Japan was detected in 1952. Mercury compound in waste water are converted by bacterial action into extremely toxic methyl mercury which can cause numbness of limbs, lips and tongue. It can also cause deafness, blurring of vision and mental derangement.



3.1.3. OIL SPILL

An oil spill is a release of liquid petroleum hydrocarbons into the environment mainly due to human activities. It includes the release of crude oil from tankers, offshore platforms, drilling rigs and wells.

Environmental impacts: Oil spills affect the physical, chemical and biological characteristics of water and land. It forms a thick black layer above the sea water and considerably increases its viscosity. This interferes with the locomotion of organisms.

The oil floating on the surface of the water reduces the penetration of sunlight, limiting photosynthesis by marine plants and phytoplanktons (producers). It will, in turn, affect the other members of the marine food chain. Oil also covers the plumage of birds and impairs their ability to fly and thus escape from predators. Birds may also ingest the oil while preening their feathers. This could result in kidney damage, altered liver function and metabolic imbalances.

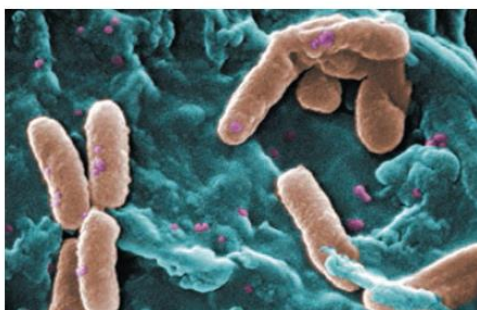
The oil which covers the coats of aquatic mammals such as seals can reduce their heat insulation capacity, resulting in hypothermia (decrease in body temperature).

Crude oil contains a mixture of volatile hydrocarbons like benzene, toluene and xylene which are carcinogenic in nature (cancer causing). Symptoms of exposure include dizziness, headaches, nausea, rapid heartbeat and dehydration.

Control and Preventive Measures

- Oil spills can be controlled by preventing the release of oil or hydrocarbons during transit, exploration or through accidents.
- Sea food should be thoroughly tested for contaminants before consumption.

Oil spills may be cleared by using certain micro-organisms such as bacteria. This process of clearing oil spills by using bacteria is known as bioremediation. One of the notable achievements in bio-remediation is the creation of *Pseudomonas putida*, a genetically engineered bacterium by an Indian American scientist, Dr. Ananda Mohan Chakraborty.



Pseudomonas putida

Pseudomonas putida is a rod-shaped saprophytic soil bacteria with the ability to breakdown hydrocarbons and organic solvents like octane and toluene.

Mumbai Oil Spill (August 2010) The spill occurred due to the collision of two oil tankers, MSV Chitra and MV Khalijia, off the coast of Mumbai. An estimated 400 tonnes of oil was spilled into the Arabian sea. The oil spill proved to cause extensive damage to the marine eco-system, as well as the sensitive mangrove plants.

3.1.4. SOIL POLLUTION

Soil pollution is the unfavourable alteration of soil by the addition or removal of substances which decrease soil productivity and groundwater quality. It usually results from human activities like dumping of waste, use of agro chemicals, mining operations and urbanization.

Causes and Effects

Industrial solid waste and sludge contain toxic organic and inorganic compounds as well as heavy metals. The radioactive waste from nuclear power plants and nuclear explosions also contaminate the soil. Fly ash contains fine particulates which are released from thermal power plants. It settles on the ground and causes pollution.

Domestic waste is rich in organic matter and undergoes decomposition. Hospital waste contains a variety of pathogens that can seriously affect human health.

Agricultural chemicals such as pesticides, insecticides and inorganic fertilizers may pollute drinking water and can change the chemical properties of the soil adversely affecting the soil organisms.

REVERSE OSMOSIS (RO)

It is the most efficient way of obtaining purified drinking water. During this process, pressure is applied on the solution which has more concentration. This reverses the natural direction of water flow and osmosis from a high gradient to a low gradient. This process involves energy expenditure. The membranes used as a barrier for RO process have a dense layer which allow only the water to pass through and prevents the passage of solutes. Hence, it is best suited for desalination of sea water (removal of salt).

Control of soil pollution

Management of soil wastes includes collection and categorization of wastes. We must also recover scrap metals and plastics for recycling and reuse and ensure safe disposal of waste with minimum environmental hazards.

Other notable methods of waste disposal include incineration (burning in the presence of oxygen) and pyrolysis (burning in the absence of oxygen). Afforestation and reforestation should be undertaken on a large scale to prevent soil erosion and loss of soil nutrients.

3.1.5.RADIOACTIVE POLLUTION

The emission of protons, electrons and electromagnetic radiations released by the disintegration of radioactive substances such as radium, thorium, uranium cause air, water and land pollution.

Effects : The ionising radiations can cause mutations.

- Strontium-90 accumulates in bones causing bone cancer.
- Iodine-131 can damage bone marrow, spleen, lymph nodes and can cause leukemia (blood cancer).

Chernobyl Disaster (Ukraine) : The explosion at the Chernobyl nuclear power station was undoubtedly the world's worst nuclear disaster. Deadly radioactive material was released into the atmosphere and the inhabitants of Chernobyl were exposed to radioactivity which was a hundred times greater than at Hiroshima. Babies were born with infirmities and people suffered from serious diseases like thyroid cancer.

Preventive Measures

- Care should be taken to prevent the leakage of radioactive substances from nuclear reactors.
- Radioactive wastes should be disposed off safely.
- Strict measures should be followed in the construction and maintenance of nuclear power plants to prevent nuclear accidents.
- Control or prevention of nuclear tests.
- We must also ensure that old batteries and radioactive parts of electronic goods are returned for recycling and not discarded into the soil or water.

3.1.6. NOISE POLLUTION

Noise may be defined as an unwanted and unpleasant sound that may have adverse effect on animals and humans. The unit of sound level is decibels (db). Noise level above 120 db is considered harmful to human beings.

Sources

The different sources associated with noise pollution are industrial machinery, road, rail and air transport, loudspeakers, construction equipments, household appliances and crackers.

Effects

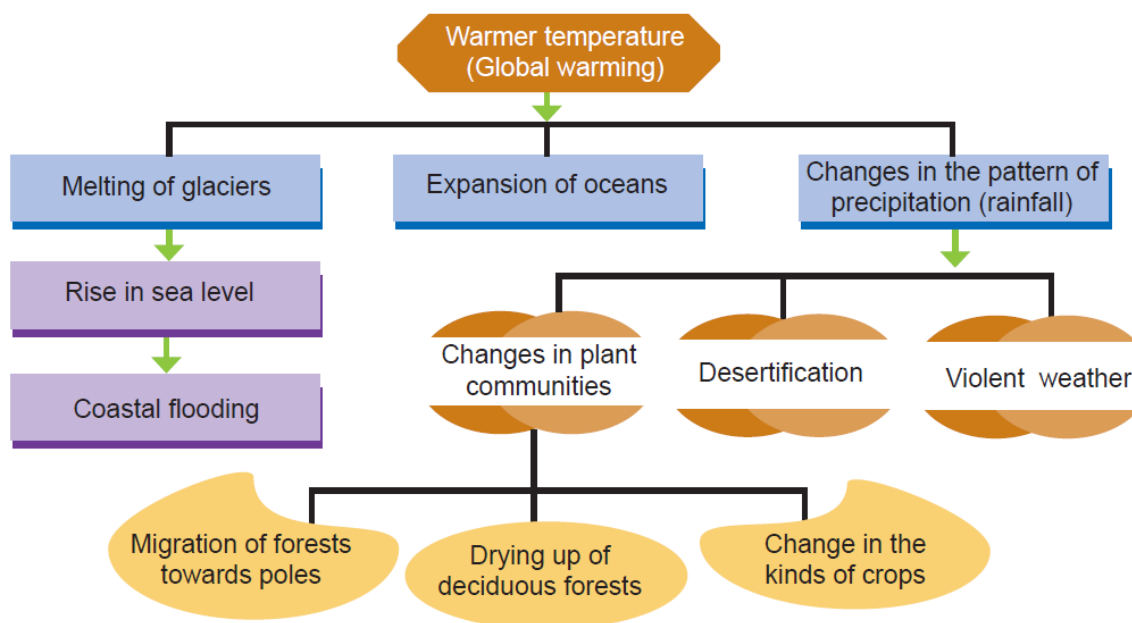
Noise seriously affects heartbeat, breathing and can cause constriction of blood vessels. It can cause headache, sleeplessness, irritability and may seriously affect the productive performance of a human. Loud noises (above 130 db) can cause damage to the ear drum, hair cells of cochlea (organ of hearing) and thereby resulting in temporary or permanent loss of hearing. It can also seriously affect the concentration of students while learning.

Jet Aircraft (take off) 145 db
Heavy city traffic 90 db
Vaccum cleaner 85 db
Window Air conditioner 60 db
Normal speech 60 db

Control Measures

Industries should be established away from residential areas. Trees should be planted along roadside or highways to reduce noise levels. Industrial machinery and motor vehicles should be properly maintained in order to minimize the noise. The use of loudspeakers and bursting of crackers should be restricted. Effort must be made to create awareness among people about the harmful effects of noise and the need to control it.

3.2. GLOBAL WARMING



- July 1998 was the hottest month the world over.
- In 1998 India had the hottest period in 50 years.
- 2012 was 9th warmest year on record. The nine warmest years have all occurred since 1998.
- There is a rapid melting of glaciers and a subsequent rise in sea level.

What could be the reason for these alarming changes in the climate and environment?

The answer is global warming. It refers to an average increase in the temperature of the atmosphere or simply it is the warming of the earth.

The root cause of this adverse climatic change is the greenhouse effect caused by greenhouse gases.

3.2.1. GREENHOUSE EFFECT

The trapping of energy from the sun by greenhouse gases in the atmosphere leading to rise in earth's temperature is known as the greenhouse effect. Greenhouse gases such as carbon dioxide, methane, nitrous oxide and chloro fluoro carbons absorb and reflect infra red waves radiated by the earth causing increase in temperature. The effect is very similar to what happens inside a greenhouse.

GREENHOUSE

A greenhouse is a structure primarily of glass or plastic in which temperature and humidity can be controlled for the cultivation or growth of plants.

Greenhouse Gases

- **Carbon-dioxide** : It is the most abundant greenhouse gas released by burning of fossil fuels, deforestation, respiration of animals, decaying of organic matter. At present there is an increase of 31% of carbon dioxide.

- **Methane:** It is produced by the incomplete decomposition of organic compounds by methanogenic bacteria under anaerobic condition. It is also produced by the enteric fermentation in the cow and from flooded rice fields.
- **Nitrous oxide:** It is released by the burning of fossil fuels, industrial processes and agricultural practices like ploughing.
- **Chlorofluorocarbons:** These are coolant gases used in refrigerators, aerosols and solvents.

Effects of Global Warming

- The level of seas rises due to the melting of glaciers and thermal expansion of water. It can submerge coastal areas of countries.
- Due to global warming the rise in temperature could create unexpected changes in weather conditions, making some regions hotter and others colder.
- The rainfall pattern could also change causing drought in some areas and flooding in others.
- Crops and forests may be affected by insect pests and plant diseases resulting in severe damage.
- Water-borne and insect-borne diseases such as malaria and dengue, could spread to temperate countries.
- It can also result in the loss of biodiversity due to the extinction of coral reefs and other key species.

Control Measures

Global warming can be controlled by reducing the use of fossil fuels, afforestation, carbon sequestration (trapping CO_2), shifting to renewable sources of energy such as solar power, wind power and hydel power.

Ten things you can do to reduce global warming:

1. Use less heat and air-conditioning.
2. Car pool, use bicycles and walk when you can.
3. Buy energy efficient products (based on the rating).

Various laws and rules have been promulgated from time to time by the Government of India to control pollution. Some of them are: 1974 - Water (prevention, control of pollution) Act. 1980 - Forest Act. 1981 - Air (prevention, control of pollution) Act. 1986 - Environmental pollution Act. 1988 - Motor Vehicles Act

4. Use CFL (Compact Fluorescent Light) bulbs.
5. Reduce, reuse and recycle resources.
6. Use less hot water.
7. "Switch off" equipment when not in use.
8. Plant trees.
9. Encourage others to conserve energy.
10. Do the energy auditing of household appliances.

Compact Fluorescent Light

CFLs are a great way to save energy even though they cost a little more and are slower to brighten up than an ordinary bulb. This is because they produce less amount of heat.

3.3. OZONE DEPLETION

The ozone layer in the stratosphere is protective in function. It filters the harmful ultraviolet rays of the sun. The ozone in this layer is continuously broken down and reformed; these two processes perfectly balance each other. Due to human activity, this balance is upset leading to the thinning of the ozone layer causing holes in the layer. The decrease in the amount of ozone in the stratosphere is called ozone depletion.



Ozone depletion

Reasons: The hole formed in the ozone layer is due to chlorine and bromine being formed in the atmosphere. The common forms are chlorofluorocarbons, methyl bromide and nitrogen oxides, which are released from freezers, air conditioners, aerosol products and industrial solvents.

Exposure to UV rays can have the following effects:

- In humans, it can cause skin cancer, cataracts and poor immune response.
- In plants, it can affect crop yield and productivity.
- The UV radiation can also cause the death of phytoplanktons (producers), young fishes and larval forms.

Control Measures

Controlling the production, use and emission of ozone depleting substances, recycling of chemicals and the adoption of measures of protection from the sun's radiation are some of the measures to control ozone depletion.

Agencies of Environmental Management C.P.R (C.P.Ramaswamy)
Environmental Education Centre Chennai:

This centre promotes environmental awareness among the public. It gives guidance for creation and implementation of environmental laws, environmental impacts and environmental management studies. It promotes the use of renewable sources of energy.

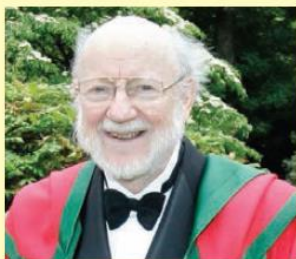
Madras Naturalists Society: It creates environmental consciousness through seminars, camps, video shows and visits to wild life sanctuaries and national parks. It conducts surveys regarding pollution and deforestation.

EL NINO EFFECT

It causes erratic weather patterns which occur due to the interaction of unusually warm or cold sea surface temperatures in the eastern and central Pacific Ocean. It was once a rare cyclical weather condition which has become more frequent, persistent and intense.

MSSRF (M.S.Swaminathan Research Foundation): It is a non-profit research organisation and was established in 1998. It carries out research and development in six major areas such as bio-diversity, bio-technology, food scarcity, coastal system research, information, education and communication.

The Nobel Prize in Physiology or Medicine 2015 was divided, one half jointly to William C. Campbell and Satoshi Omura "for their discoveries concerning a novel therapy against infections caused by roundworm parasites" and the other half to Youyou Tu "for her discoveries concerning a novel therapy against Malaria".

Field : Physiology / Medicine

William C. Campbell

Born: 1930, Ramelton, Ireland.
Affiliation at the time of the award: Drew University, Madison, New Jersey, USA.



Satoshi Omura

Born: 1935, Yamanashi prefektur, Japan.
Affiliation at the time of the award: Kitasato University, Tokyo, Japan.



Youyou Tu

Born: 1930, Zhejiang Ningpo, China.
Affiliation at the time of the award: China Academy of Traditional Chinese Medicine, Beijing, China.

58] Periodic Classification Of Elements

When you go to a big library, you see many racks with books. If you need a book on Science, you would go to the section labelled as Science. In the Science section you will find separate racks for various branches like Chemistry, Physics etc. where books are arranged in a certain order. Thus, wherever a large number of items are involved, proper classification is needed for easy identification.

In the early days, when elements were being discovered, scientists tried to classify elements based on their nature, and then according to their atomic mass. This classification of elements is called 'periodic table'. Finally, they succeeded with a classification system based on atomic number. In this periodic table, elements which show similar physical and chemical properties are arranged in rows and columns. This table also led to the discovery of elements not known till then.

EARLY ATTEMPTS AT 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 together into what he termed triads.

Elements with similar chemical properties were 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 were grouped together into a triad as shown below. The atomic mass is shown in brackets.

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

After the discovery of elements many of them could not be grouped this way.

Newland's Classification of Elements

In 1863, John Newland arranged the elements in the increasing order of Atomic Mass. He observed that there appeared to be a repetition of similar properties in every eighth element like that of eighth note in an octave of music.

Therefore, he placed seven elements in each group. Then he classified the 49 elements known at that time into seven groups of seven each. Newland referred to this arrangement as the Law of Octaves.

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. Likewise, Magnesium is similar to Beryllium.

More to know

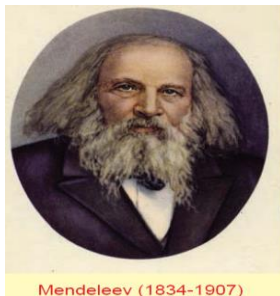
Chemically alike elements could be arranged in a group of three, in which the atomic mass of the middle element would be approximately the arithmetic mean of the two extreme elements.

Limitations of Newland's Classification

Inert gases were discovered at a later stage. With the inclusion of inert gas, 'Neon' between 'Fluorine' and 'Sodium', the 9th element became similar to the first one. Similarly, the inclusion of inert gas 'Argon' between 'Chlorine' and 'Potassium' made the 9th element similar to the first one.

Lothar Meyer's Classification of Elements

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



Dimitri Ivanovich Mendeleev, a Russian chemist, suggested that the chemical elements can be sorted out based on 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.

More to know

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

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)

MENDELEEV'S CLASSIFICATION OF ELEMENTS

Mendeleev's periodic table is based on 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".

Characteristics of Mendeleev's Periodic Table

- Mendeleev felt that similar properties occurred after periods (horizontal rows) of varying length.
- He created a table with eight columns.
- He left a few cells empty so that all the elements with similar properties could be grouped in the same column.
- Mendeleev inferred that there must be other elements that had not yet been discovered.

- He predicted the properties and atomic masses of several elements that were not discovered at that time. Later on, when these elements were discovered, their properties remarkably agreed with his prediction

For example, he left a gap below silicon in group IV A, and called the yet undiscovered element as 'Eka Silicon'. The discovery of 'Germanium' later on, during his lifetime, 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	5.47
3. Colour	Dark grey	Dark grey
4. Formula of Oxide	EsO ₂	GeO ₂
5. Nature of Chloride	EsCl ₄	GeOl ₄

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

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 0.
4. Groups I to VII are subdivided into subgroups 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 yet 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.

Modified Mendeleev's Periodic Table

Group ↓ Periods →	I	II	III	IV	V	VI	VII	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	58.93 Co 27	83.90 Kr 36
5	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		
	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	102.91 Rh 45	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	192.2 Ir 77	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** 89						

6	Lanthanides	140.12 Ce 58	140.91 Pr 59	144.24 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

More to know

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

Limitations of modified Mendeleev's Periodic Table

1. A few elements that have a higher atomic mass were placed before those 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. Hydrogen was placed in group IA although its properties resembled elements in group IA as well as group VIIA.
4. Chemically dissimilar elements were placed in the same group.

For example, alkali metals like sodium and potassium were placed along with coinage metals like copper, silver and gold.

More to know

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

METALS AND NON-METALS

All the elements in the periodic table are broadly divided into three categories.

- Metals
- Non-metals
- Metalloid (semi-metals)

Metals

Metals are a group of elements which have similar properties. Most of the known elements are metals and they occupy a large area in the periodic table. The left side of the periodic table contains metals. Metals are further classified into:

More to know

- Tungsten has the highest melting point of over 3300°C.
- Lithium is the lightest metal. It weighs about half as much as water.
- Osmium is the heaviest metal. It is about 22½ times heavier than water and nearly 3 times heavier than iron.

i. Alkali metals

e.g. sodium and potassium

ii. Alkaline earth metals

e.g. calcium and magnesium

iii. Transition metals

e.g. iron and nickel

iv. Other metals

e.g. aluminium, tin.

Non-metals

Elements that do not exhibit the properties of metals are called non-metals. Non-metals occupy the left side of the periodic table. e.g. Carbon, Iodine.

Metalloids

Elements which have the properties of both metals and non-metals are called metalloids. They are very good semi-conductors

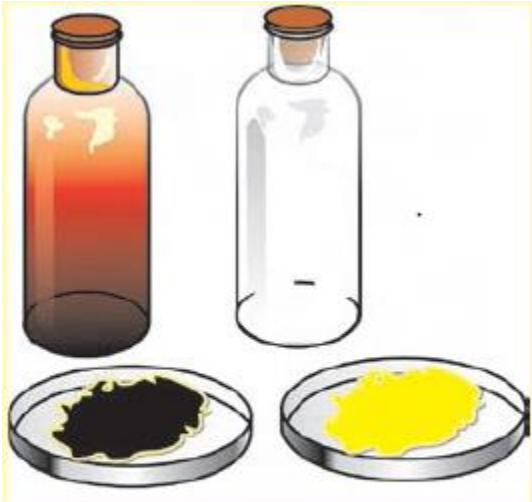
e.g. Silicon, Germanium.

More to know

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

PHYSICAL PROPERTIES OF METALS AND NON-METALS

S.No	Properties	Metals	Non-Metals
1	Appearance	Have a lustre, known as	Have no lustre and look dull.

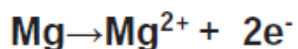
		metallic lustre. The surface is polishable.  Platinum Gold Silver	Surface cannot be polished. (Exceptions: Graphite and iodine are lustrous).  Yellow - Sulphur, White - Phosphorous, Red - Bromine, Black-Carbon
2	Physical state	In general, they are hard crystalline solids. (Exception: Mercury is a liquid).	They exist as soft solids or gases. (Exceptions: Diamond is a hard solid and bromine is a liquid).
3	Density	They have a high density. (Exceptions: Sodium and Potassium).	They have a low density
4	Melting and boiling Points	Usually they have high melting and boiling points. (Exceptions: Sodium and Potassium).	They have low melting and boiling points. (Exceptions: Diamond and graphite).
5	Malleability and ductility	They are malleable and ductile.	Solid non-metals are brittle.

6	Heat conductivity	They are good conductors	They are bad conductors. (Exception: Diamond).
7	Electrical Conductivity	They are good conductors	They are bad conductors. (Exception: Graphite)
8	Sonority (phenomenon of producing a characteristic sound when a material is struck)	They are sonorous.	They are non-sonorous. (Exception: Iodine crystals produce a soft metallic clink when they are shaken in a bottle).
9	Alloy formation	Metals form alloys with each other and also with some non-metals	Non-metals usually do not form alloys. (Exceptions: B, C, Si and P form alloys with metals).

CHEMICAL PROPERTIES OF METALS

1. Electropositivity:

Metals are electropositive. They lose electrons and form cations.



2. Reaction with Oxygen:

Metals combine with oxygen to form metallic oxides.

i. Magnesium burns in oxygen to form magnesium oxide.





Magnesium burns in oxygen

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



Formation of aluminium oxide over a surface of aluminium

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



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

Note: Metal oxides are mostly basic in nature though some are amphoteric. (Shows both acidic and basic properties)

3. Action of water

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



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



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



Other metals like copper, nickel, silver and gold do not react with water.

4. Action of acids on metals

Metals such as sodium, magnesium and aluminium react with dilute hydrochloric acid to give the respective salts. Hydrogen gas is liberated.



5. Action of halogens

Metals react with halogens to form ionic halides.



6. Reducing property:

When a reactant gains electrons during the reaction, it is said to be reduced. In a chemical reaction between a metal and a non-metal, the metal loses one or more electrons, which are accepted by the non-metal. So the metal is oxidised and the non-metal is reduced. The metal acts as a reducing agent.



CHEMICAL PROPERTIES OF NON-METALS

1. Electronegativity:

Non-metals are electronegative. They gain electrons and form anions.



2. Reaction with oxygen:

Non-metals when heated with oxygen produce covalent oxides.

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



2. Phosphorous burns in air to form phosphorous pentoxide.



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



Note: Most of the non-metal oxides are acidic in nature. Some of them are neutral oxides.

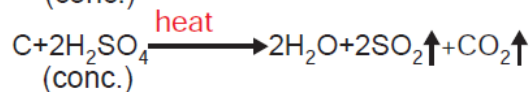
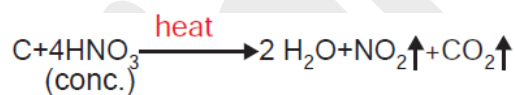
3. Action of water:

Carbon reacts with water to form carbon monoxide and hydrogen.



Action of acids on non-metals:

Generally non-metals do not react with acids, but when they are heated with conc. HNO_3 or conc. H_2SO_4 , the respective oxides or oxoacids are formed.



5. Action of chlorine:

Non-metals react with chlorine to form covalent chlorides.



6. Oxidising property:

When a reactant loses electrons during a reaction, it is said to be oxidised. In a chemical reaction between a metal and a non-metal, the metal loses one or more electrons, which are accepted by the non-metal. So the metal is oxidised and the non-metal is reduced. The non-metal acts as an oxidising agent.



REACTIVITY SERIES

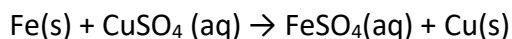
The reactivity series or activity series is the arrangement of some common metals according to their reactivity. The reactivity of the metals decreases as we go down. The two non-metals, hydrogen and carbon, are included in the series to compare the reactivity of the metals above and below them in specific reactions.

Reactivity series of metals:	
Potassium	 Most reactivity
Sodium	
Calcium	
Magnesium	
Aluminium	
Carbon	
Zinc	
Iron	
Tin	
Lead	
Hydrogen	Least reactivity
Copper	
Silver	
Gold	
Platinum	
C and H are added for comparison	

USES OF REACTIVITY SERIES

1. Highly reactive metals occupy the top portion of the series. They readily react with other chemical compounds. Most of the reactions are exothermic.
2. The electropositive nature of metals decreases as the reactivity decreases. So the reducing nature of metals decreases too.
3. The metals above hydrogen in the reactivity series displace hydrogen from water.
4. The metals above hydrogen in the reactivity series react with dilute acids and liberate hydrogen gas. Lead is an exception.
5. A more reactive metal can displace a less reactive metal from its salt solution.

Example:



6. The reactive metals are susceptible to corrosion.
7. Metals above carbon cannot be extracted from their carbon ores.

ALLOYS

The idea of making alloys is not new. It was known to people of ancient times. Thousands of years ago, people discovered that they could use copper instead of stone to make tools. Around 3500 B.C., people discovered the alloy called “bronze”. They combined tin, a fairly soft metal, with copper to produce bronze. Bronze is a very hard alloy and is used for many purposes. Bronze prove to be a better material, when compared to tin or copper.

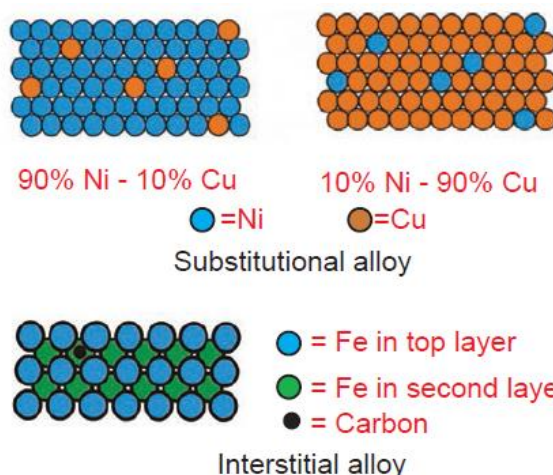
An alloy is a homogeneous mixture consisting of two or more metals fused together in the molten state in a fixed ratio.

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.



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.

USES OF ALLOYS

Name of the alloy	Metals present in it	Uses
Brass	Copper, Zinc	To make screws, windows and door fittings
Bronze	Copper, Tin	To mould statues, machine parts
Solder	Tin, Lead	In electrical and plumbing industries, to join metal surfaces without melting them.
Steel	Iron, Carbon, Chromium, Nickel, Tungsten	In construction of bridges, buildings, household products, cooking utensils
Duralumin	Aluminium, Copper, Manganese, Magnesium	To manufacture aircraft parts, cars, ships and nails.

Characteristics of alloys

1. An alloy is harder than the metals in it.
2. An alloy enhances the tensile strength of the base metal.
3. An alloy improves corrosion resistance.
4. The density and melting point of the individual metal is different from the density and melting point of the alloy.
5. An alloy enables better castability.

More to know

- Ferrous alloys contain iron as the base metal.
- Non-ferrous alloys contain a little iron or no iron.
- Amalgam is an alloy in which one of the constituents is mercury.

59] Chemical Bonds

In a garland, flowers are strung together with a thread. Unless the flowers are tied, they cannot be held together. The role of the thread is to hold all the flowers together. Similarly, a bond holds the atoms in a molecule together.

Two or more atoms are joined together by a force to form a stable molecule. This force is referred to as a 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.

OCTET RULE

Gilbert Newton Lewis used the knowledge of electronic configuration of elements to explain “why atoms are joined to form molecules”. He visualized that inert (noble) gases have a stable electronic configuration, while atoms of all other elements have an 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 either by electron transfer or by 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 the “octet rule” or “Rule of eight”.

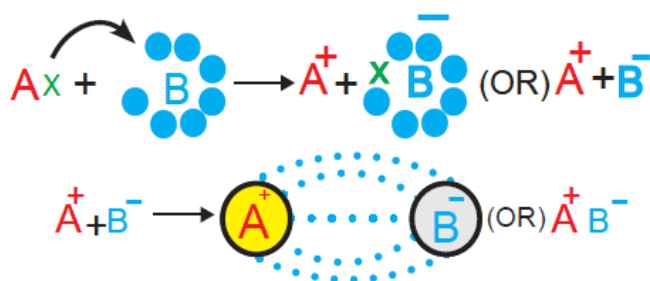
TYPES OF CHEMICAL BOND

Scientists have recognized three different types of bonds. They are:

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

FORMATION OF IONIC AND COVALENT BONDS**1. Formation of ionic (or) electrovalent bond**

Let us consider two atoms A and B. Atom A has 1 electron in its valence (outermost) shell. Atom B has 7 electrons in its valence shell. A has 1 electron more and B has 1 electron less 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. The formation of ionic bond between A and B can be shown as:

**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

More to know

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

Lewis Symbol	Electron distribution	Valence electrons
$\cdot\text{H}$	(1)	1
$\cdot\text{Be}\cdot$	(2, 2)	2
$\cdot\text{B}\cdot$	(2, 3)	3
$\cdot\text{C}\cdot$	(2, 4)	4
$\cdot\text{N}\cdot$	(2, 5)	5

Thus the 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”. Factors 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) Low ionisation energy

If the ionisation energy of A is lower, it easily loses electrons and forms a cation. So, metals which have low ionisation energy tend to form ionic bonds.

(iii) 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.

(iv) Attraction towards electrons

Atoms A and B should differ in their attracting powers towards electrons. 'A' has less attraction for electrons and hence gives off the electron while 'B' has more attraction towards electrons and hence gains electrons.

More to know

Electronegativity is the tendency of an atom to attract bonded pairs of electrons towards itself in a molecule. Electrostatic attraction is found between oppositely charged ions. It is also known as coulombic force of attraction.

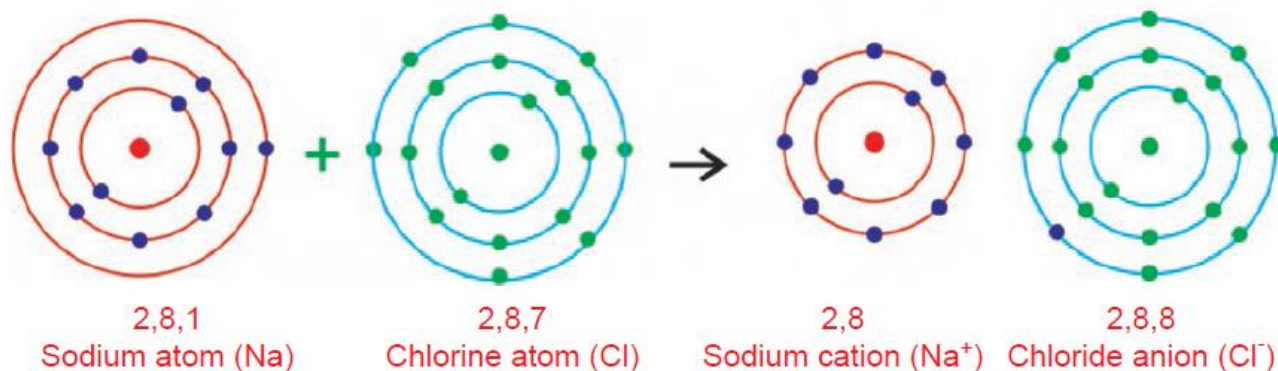
Illustration: 1

Formation of Sodium chloride

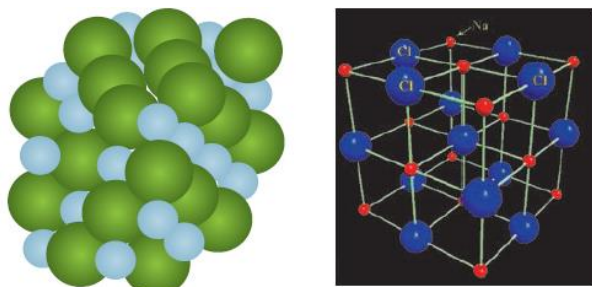
Sodium has one valence electron while chlorine has 7 valence electrons.

Sodium atom transfers the electron to chlorine atom and thus both the atoms achieve stable octet electronic configuration.

Atom	Atomic number	Electron distribution
Sodium	11	2, 8, 1
Chlorine	17	2, 8, 7



Sodium (Na) becomes sodium cation (Na⁺) and chlorine (Cl) becomes chloride anion (Cl⁻). Both the ions are joined together by an 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.



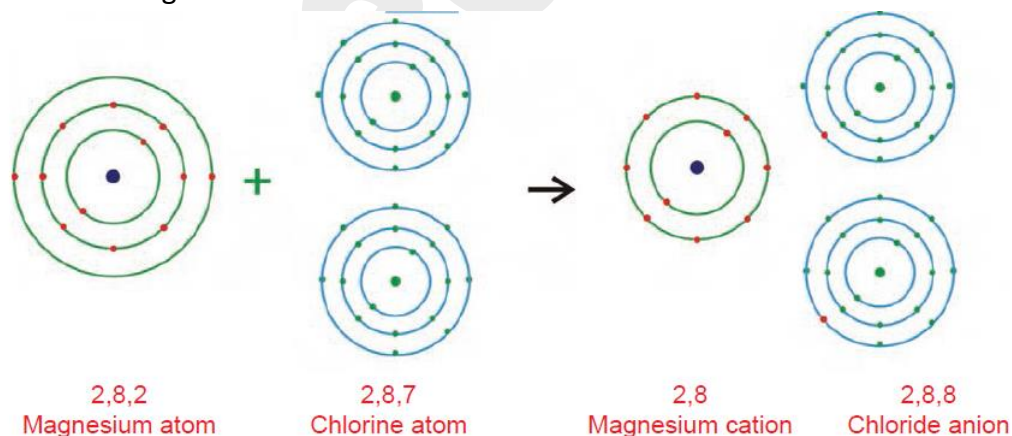
Structure of sodium chloride

Illustration: 2**Formation of Magnesium chloride**

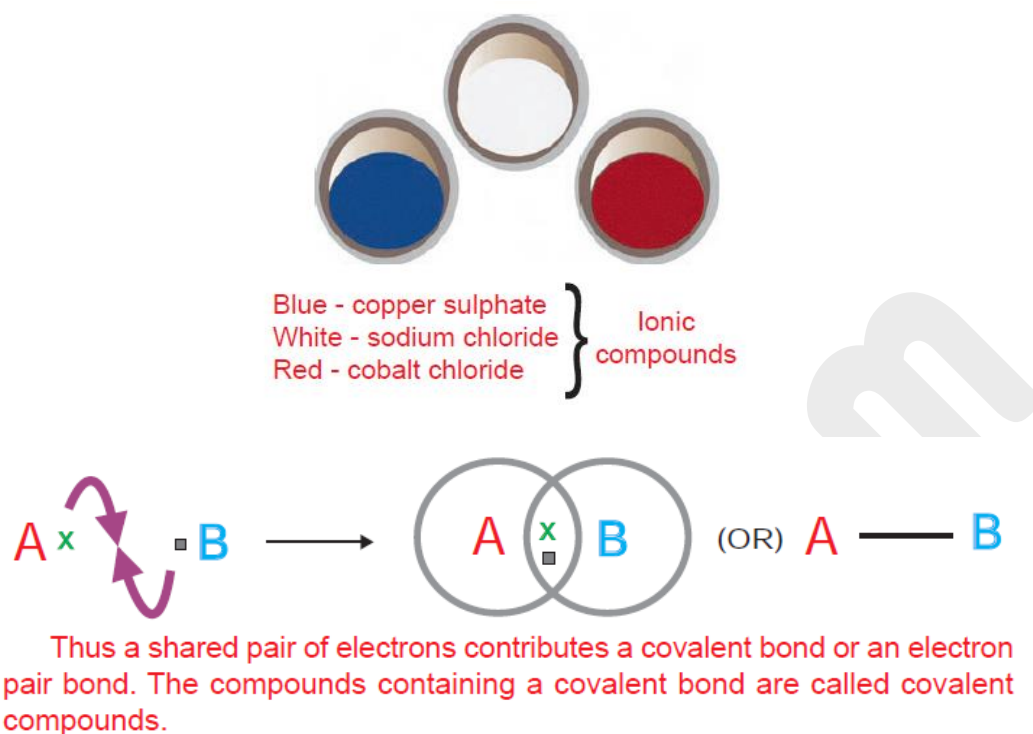
Atoms	Atomic number	Electron distribution
Magnesium	12	2, 8, 2
Chloride	17	2, 8, 7

Magnesium has 2 valence electrons while chlorine has 7 valence electrons. Magnesium atom gives 2 electrons. Each chlorine atom receives one electron and thus all 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. 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.



Factors which favour the formation of covalent bond:

- (i) **Number of valence electrons** : A and B should have 5, 6 or 7 valence electrons so that both of them achieve a stable (octet) electronic configuration by sharing 3, 2 or 1 electron pair.
- (ii) **High ionisation energy** : If A has high ionisation energy, it is unable to lose its valence electrons easily. The cation formation is difficult. So A prefers covalent bonding.
- (iii) **Equal electronegativities** : When A and B have equal electronegativities, electron transfer from one atom to another does not take place. Thus the bond formed between A and B is covalent.
- (iv) **Equal electron gain enthalpy** : When A and B have equal electron gain enthalpies, A and B exhibit an equal attraction towards the bonded pair of electrons. So the bond formed between A and B is covalent.

Illustration: 1

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 a stable electronic configuration.

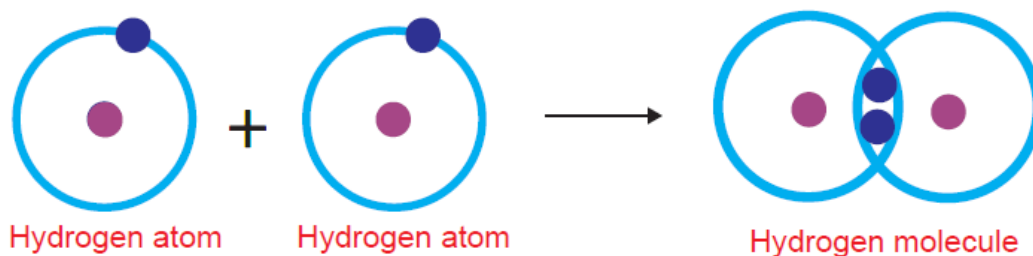
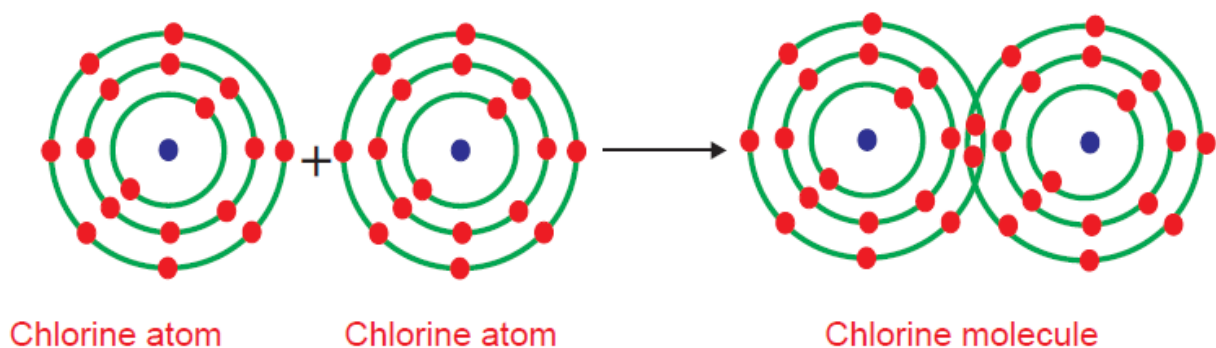
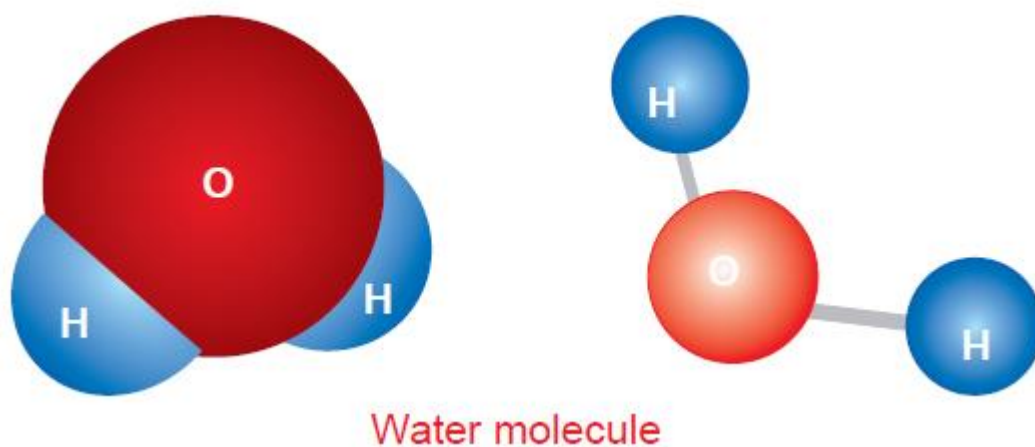


Illustration: 2**Formation of chlorine molecule**

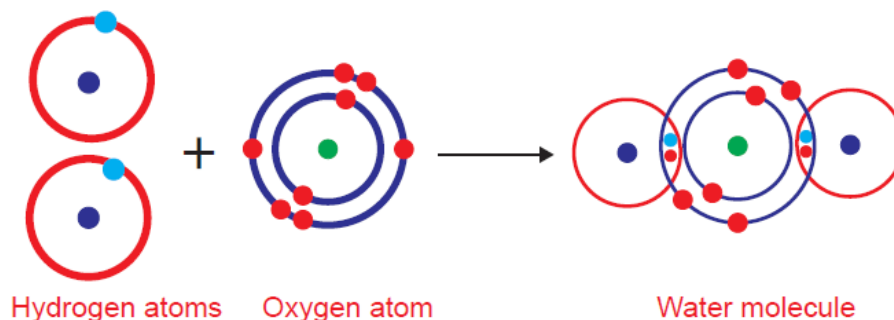
Each chlorine atom (2, 8, 7) has seven valence electrons. Each of them shares an electron and attains a stable electronic configuration.

**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.

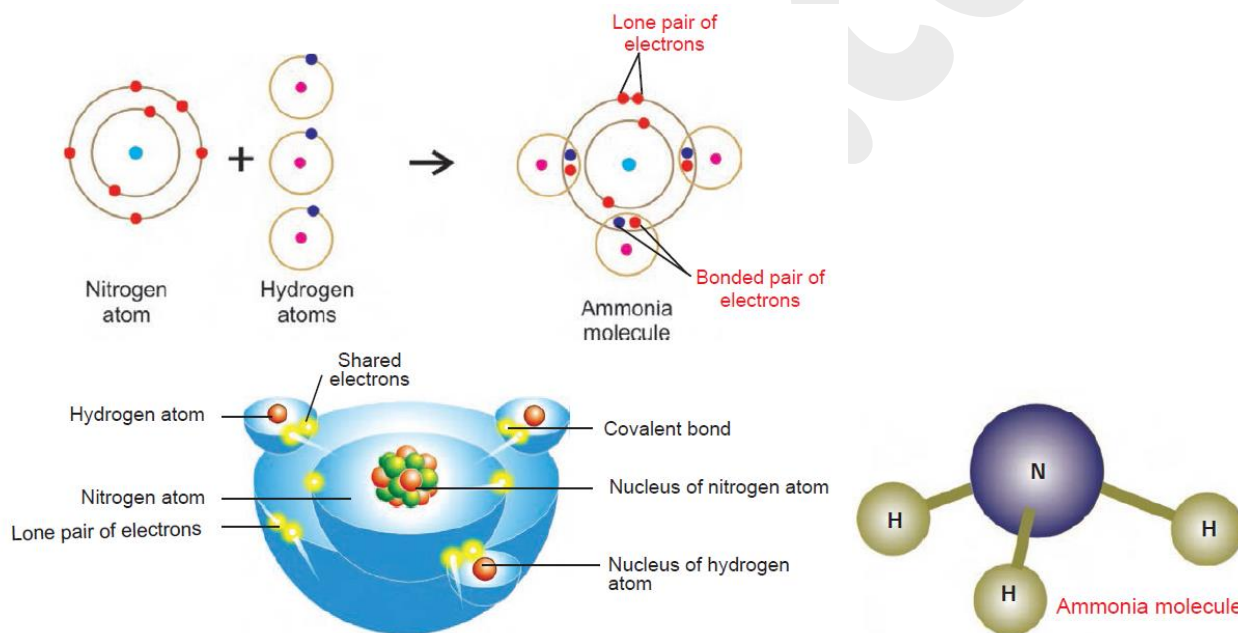
**More to know**

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

**Illustration: 4****Formation of ammonia molecule**

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

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

**More to know**

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

COMMON PROPERTIES OF IONIC COMPOUNDS**Solids at room temperature**

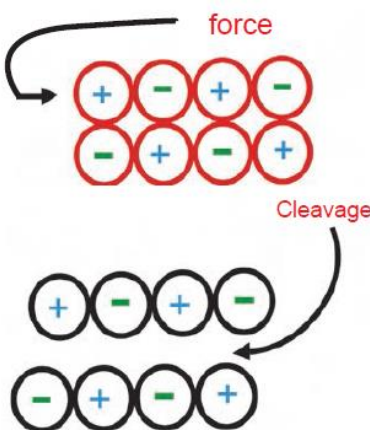
On account of strong electrostatic force between the opposite ions, these ions do not have a free movement. Hence ionic compounds are solid at room temperature.

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, a slight shift takes place bringing like-ions in front of each other. It causes repulsion and cleavage.

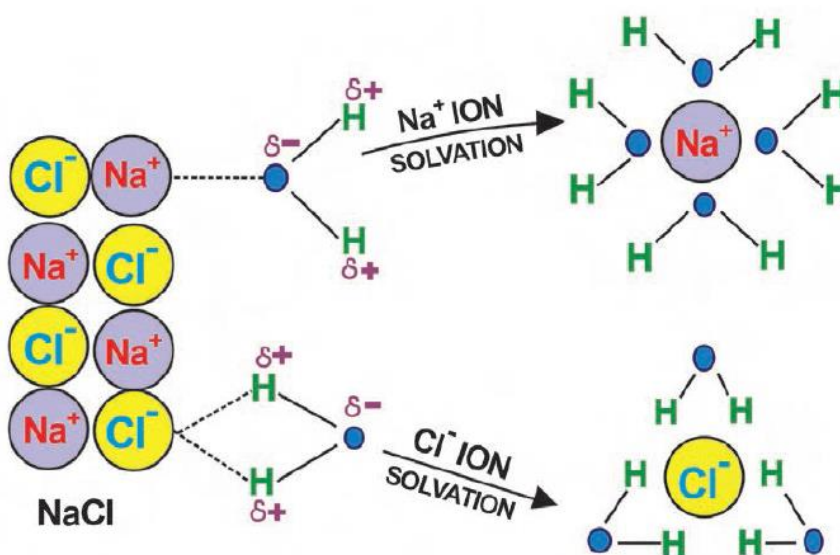


More to know

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.



Conductors of electricity

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

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 liquids.

Soft solids

A molecular layer in the crystal easily slips relative to adjacent layers.

Thus the crystals are easily broken.

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.

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.

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. Therefore there is no electrical force to speed up the reactions, these reactions are slow.

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 and 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.

COORDINATE COVALENT BOND

In a normal covalent bond, the bond is formed by mutual sharing of electrons between the combining elements. If the shared pair of electrons are contributed only by one of the combining elements, the covalent bond is called coordinate covalent bond or coordinate bond or dative bond.

Thus, the 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. The atom which donates electron pair is called 'donor atom' and the atom which accepts electron pair is called 'acceptor atom'.

A coordinate covalent bond is represented by an arrow ' $\rightarrow$ '.

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



More to know

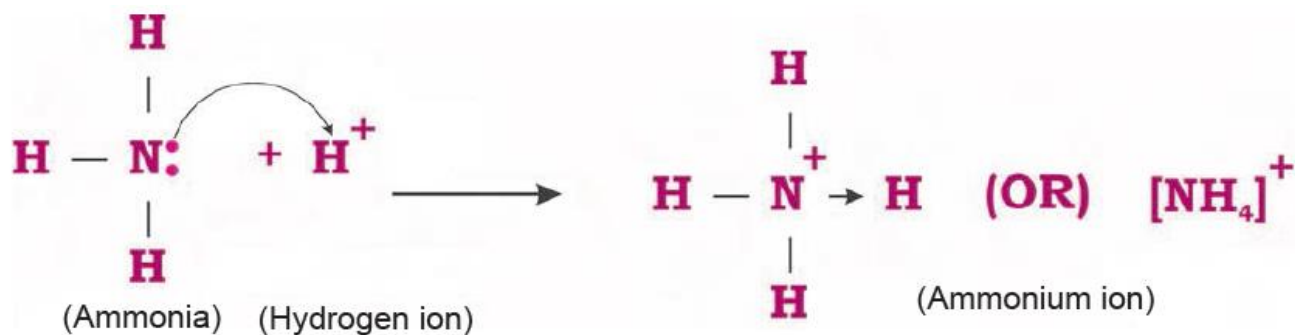
Sharing of two pairs of electrons makes a double bond. Sharing of three pairs of electrons makes a triple bond. These are called multiple covalent bonds.

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

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 still nitrogen has an unshared pair of electrons. Nitrogen donates this lone pair of electrons to hydrogen ion of an acid forming ammonium ion.



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 that of 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, in short of the octet or in excess of the octet.

(i) Four electrons around the central atom

Berylliumdichloride (BeCl_2)

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 in a liquid state as a result of the great polarity of water molecules.

	Beryllium	Chlorine
Atomic number	44	17
Electron distribution	2, 2	2, 8, 7
Valence electrons	2	7

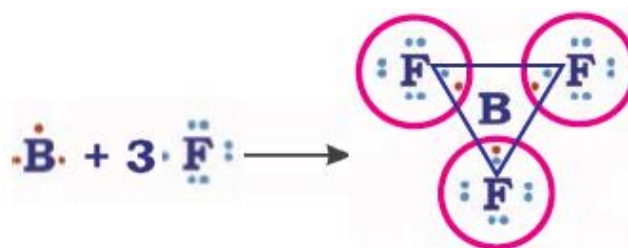


Each chlorine atom is surrounded by 8 electrons but a beryllium atom has only 4 electrons around it.

(ii) Six electrons around the central atom

Borontrifluoride (BF₃)

	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 a boron atom has only 6 electrons around it.

More to know

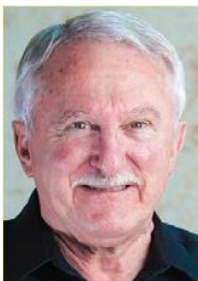
The Nobel Prize in Chemistry 2015 was awarded jointly to Tomas Lindahl, Paul Modrich and Aziz Sancar "for mechanistic studies of DNA repair".

Field : Bio-Chemistry



Tomas Lindahl

Born: 1938, Stockholm, Sweden Affiliation at the time of the award: Francis Crick Institute, Clare Hall Laboratory, Hertfordshire, United Kingdom



Paul Modrich

Born: 1946 Affiliation at the time of the award: Howard Hughes Medical Institute, Duke University School of Medicine, Durham, North Carolina, USA



Born: 1946, Savur, Turkey. Affiliation at the time of the award: University of North Carolina, Chapel Hill, North Carolina, USA

60] Work, Power And Energy

In earlier classes, you have learnt about wind energy, solar energy and how electrical energy can be generated from chemical energy in a battery or cell. You have also learnt about non-renewable and renewable sources of energy. In this chapter, you will learn:

- How to define and explain 'work', 'power' and 'energy' with examples.
- The different forms of energy, in particular, kinetic and potential energy.
- The law of conservation of energy.

WORK

We shall first learn about 'Work'. When we write or read or when we lift or move an object like a chair; in everyday language we call it 'work'. In physics, however, the word 'work' has a very specific definition and is related to force and movement.

Work is said to be done, when a force acts on a body and the point of application of the force is displaced in the direction of force.

We must note that when a force acts on a body at rest, it results in acceleration, which in turn results in velocity and displacement. In the definition of work, however, we are merely concerned about the resultant displacement and not the rate at which the displacement happens (velocity).

- i. If the body is displaced in the same direction as the force, then work is said to be done by the force.

- ii. If the body is displaced in the opposite direction to that of the force, then work is said to be done by the body against the force.
- iii. If the body is displaced in the direction perpendicular to that of the force, then no work is done either by the force on the body or against the force. The work done is said to be zero.

When a cart man applies a force on the cart and the cart moves forward, then work can be said to be done by the force applied by the cart man on the cart.

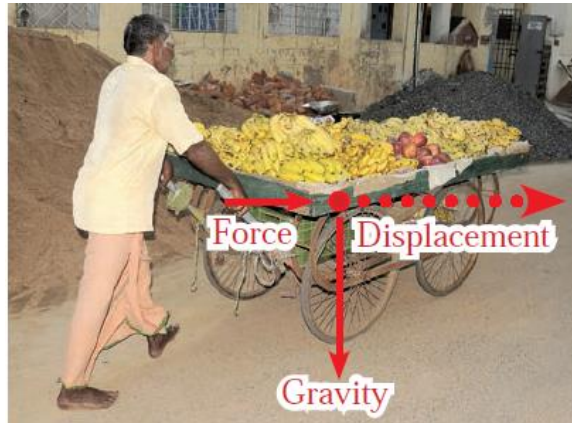


Fig. 6.1. work done by a force

The weight of an object is the force of gravity acting on the object. When the object is lifted up from the ground to a point above, then work is said to be done against the force of gravity.



In the example of the cart man pushing the cart, no work is done by the force of gravity and no work is done against it, since the displacement is perpendicular to the force of gravity.



Work (W) is measured as the product **James Prescott Joule** of the force (F) and the displacement (S) in the direction of the force.

$$W = F \times S$$

When work is done by a force, then both force and displacement are positive and the work done is also positive. When work is done against the force, then force has a positive sign but displacement has a negative sign and the work done has a negative sign.

The SI unit for measuring the quantity of work done is the joule. One joule of work is said to be done when a force of one newton acting on a body displaces it by one metre. The SI unit of work is named after

James Prescott Joule an eminent British scientist who was one of the pioneers in the field of work and energy.

For example, if a force of 10N acting on a football moves it by 20m in the same direction as the applied force, then the work done is calculated as follows:-

$$W = F \times S = 10\text{N} \times 20\text{m} = 200\text{J}$$

Imagine lifting a small apple or a large banana (about 100g) through a height of one metre. This would amount to one joule of work. It is a very small quantity of work. To measure larger quantities of work, we use larger units of work such as the kilo joule (10³ joules) and the mega joule (10⁶ joules).

POWER

In everyday language, the word 'power' is often used to imply 'a large force or electric power supply' and the word 'powerful' to mean 'strong'. In physics, the word "power" has a very specific definition and is related to work.

Power (P) is defined as 'the rate of doing work'. It can also be defined as 'the work done per unit time'.

Imagine a young boy running up a flight of stairs in 10 seconds and an old man climbing up the same flight of stairs in 20 seconds. The work done by both of them is the same. The boy, however, does it in lesser time. The boy is said to be producing more power than that of the old man. The boy produces twice as much power as the old man.



Power (P) is calculated by dividing the work done (W) by the time taken (t) to do that work.

$$\text{Power} = \frac{\text{work done}}{\text{time taken}}$$
$$P = \frac{W}{t}$$

The SI unit for measuring power is Watt. Power is said to be one watt when one joule of work is done in one second. One watt of power is the same as one joule per second. The SI unit of power is named after the Scottish inventor and engineer, James Watt.

Imagine lifting a small apple or a large banana (about 100g) through one metre in one second. This would amount to one watt of power. If the same work is done in two seconds, it would amount to half a watt. The watt is a fairly small unit of power. To measure larger quantities of power, we use larger units of power such as the kilowatt (10^3 watts) and the megawatt (10^6 watts).

James Prescott Joule



James Prescott Joule experimentally established that a pound weight falling through seven hundred and seventytwo feet could generate enough heat to raise the temperature of a pound of water exactly by one degree Fahrenheit, thus establishing the equivalence between the amount of work done and the quantity of heat produced. The SI unit of work is named after him. He also established the law according to which, heat is produced in a conductor of electricity when electric current is passed through it. He also established the equivalence among the quantity of electric work, the quantity of heat energy and the quantity of mechanical work.

ENERGY

Energy is defined as the capacity to do work. We must note that by definition the concepts of energy and work are related to each other. Energy is invisible but work is not. So when we see work being done, we conclude that energy must be present for that work to be done. Usually an object (or even a liquid or gas) generates the force that does the work. Therefore energy is associated with the object (or liquid or gas) that generates the force which does the work. For example, when water is boiled and steam is released, the steam can generate a force that can move a whole train.

We can, therefore, conclude that the steam must have had energy, since it has done a work. When a leaf sways due to the force of the wind, then work is done by the wind and wind must have had energy that was used to do the work. If X units of work is done we assume that the same number of units of energy must have been used up and the energy within the object or agency doing the work must have been reduced by the same quantity.

The SI unit for measuring energy is the same as that of measuring work, which is the joule. The larger units for measuring energy are also correspondingly kilo joule and mega joule.

The practical unit of measuring electrical energy is the kilowatt-hour which is also colloquially referred to as “unit”.

One kilowatt-hour is the energy consumed at the rate of one kilowatt for one hour. This

is equivalent to 3600000J [$1000\text{W} \times 3600\text{s} = 3600000\text{J}$
 $= 3.6 \times 10^6 \text{ J}$].

Example: How much electrical energy will be consumed when a hundredwatt bulb is used for 10 hours?

Energy = 100 watt x 10 hour

= 0.1kW x 10h = 1kWh.

Different forms of energy

Anything that can do work contains energy. We understand that heat can do work from the example of the steam engine. Therefore, heat is a form of energy. Electricity can produce heat when it is passed through a resistance.

Electricity is also used to run fans and lights. Therefore, electricity must also be a form of energy. Wind can be used to do work and so it is also a form of energy. Thus there are various forms of energy and all of them can perform some work. Some important forms of energy are: chemical energy, light energy, heat energy, electrical energy, nuclear energy, sound energy and mechanical energy. We shall discuss mechanical energy with a little more detail, later in this chapter.

James Watt (1736- 1819)



A Scottish inventor and mechanical engineer James Watt was interested in the technology of steam engines. Watt improved the efficiency of the steam engine greatly and its cost-effectiveness.

OBTAINING ENERGY

In the preceding section, we spoke about how energy gets lost by steam (or any other object) while doing work. The question that naturally arises is: “Where does an object get its energy from?” The answer to this question leads us to one of the most important laws in mechanics after Newton’s Laws.

An object can acquire energy in two different ways. It can get energy when,

(i) energy in some other form is converted and added to the energy that the object already possesses. Energy can never be created.

(ii) work is done.

More to know

The earliest evidence for controlled use of fire was found at an Early Stone Age excavation site in the Middle east, (now Israel) 790,000 years ago, from where charred wood and seeds were recovered. Evidence also shows that human beings have used wind from about 3500 BCE.

Systematic use of these elements from nature (earth, water, wind and fire) to do pieces of work, which human beings would otherwise have had to do with their own hands started from the time of the Greeks around 200 BCE. Yet, surprisingly, it was not until 1802 that the term 'energy' was used in the modern scientific sense for the first time.

Even more surprising is the fact that importance was not given to the concept of energy, till the late nineteenth century, when two important concepts were proven beyond doubt.

The first was that 'energy' could neither be created nor destroyed and that it could only be converted from one form to another. The second was that every time energy is converted from one form to another, a part of that energy is invariably converted into a form that is not usable thereafter (loss of energy). Let us learn more about these two concepts.

OBTAINING ENERGY THROUGH ENERGY CONVERSION – THE LAW OF CONSERVATION OF ENERGY

The law of conservation of energy states that:

'Energy can neither be created nor destroyed; it can only be changed from one form to another.'

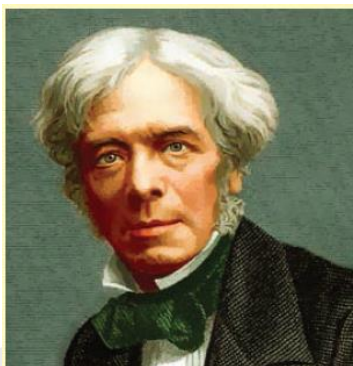
A car engine burns fuel, converting the fuel's chemical energy into heat energy, which in turn is converted into mechanical energy to make the car move. Windmills transform wind energy into mechanical energy, which can be used to turn a turbine to produce electricity. The electrical energy can be changed into light energy in a bulb. It can also be converted into mechanical energy, to turn a fan or changed into heat energy to cook food. The cooking of food itself is a chemical reaction which can be turned into energy inside the human body. Going backwards on the chain of energy transformation, the wind energy comes from the heat energy flowing from the sun and the sun's energy itself comes from nuclear reactions within the sun.

In fact, if you take any form of energy, you will find that it is obtained from another form of energy; and that form of energy has been obtained from another; to form an endless chain of transformation of energies without a beginning or an end. That is an awesome fact and you should pause to think over the enormity of it!! Therefore when we say, we are using energy what we really mean is that we are converting one form of energy into another form.

THE ALTERNATIVE STATEMENT OF THE LAW OF CONSERVATION OF ENERGY

The Law of Conservation of Energy can also be stated as follows: 'The total amount of energy in an isolated system remains constant but can be transferred from one object to another within the system.'

Michael Faraday (1791-1867)



Michael Faraday was perhaps the first person to point out the interconnections between various phenomena. He pointed out that from chemical reactions come electricity: from electricity comes magnetism: from magnetism, we can obtain electricity, from electricity we can go back to chemical reactions. He knew fully well that none of these can be produced endlessly from another. "Nowhere," he says, "is there a pure creation or production of power without a corresponding exhaustion of something to supply it."

He was very close to it but narrowly missed articulating the all-important Law of Conservation of Energy in its exact form. Faraday was still alive, when many scientists working for nearly fifty years came to the conclusion that energy could neither be created nor destroyed and articulated it in the modern form as the Law of Conservation of Energy.

What is a system?

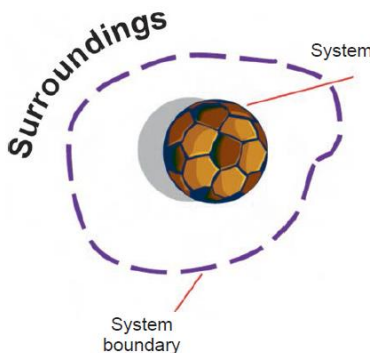
When we study an object, we usually fix our attention on the object and analyse the various aspects of it. The object of our study is usually referred to as a system. Sometimes the system may consist of more than one object. It is useful to think of our system as separate from everything else.

To do this, we draw a boundary around the object. Sometimes the boundary is real. At other times, a simple imaginary boundary will do. Everything else outside the boundary is referred to as its surroundings.

The surroundings interact with the object and influence it. We can visualize these interactions as crossing the boundary to interact with the object. When there are no influencing factors on the system from the surroundings, then we call it an isolated system or a closed system.

Explanation for the Alternative Statement of the Law of Conservation of Energy

The alternative form of the Law of Energy states that the total energy within the closed system remains a constant in the absence of any interaction with the surroundings. You can now understand that both the statements of the conservation law mean almost the same.



GETTING ENERGY FROM WORK

When an object generates the force that does work, then there is a decrease in energy in that object. On the other hand, when the force generated by some other agency acts on an object and does a work, then the object's energy increases. In this case, we say that the work is done on the object.



Energy gained by an object is measured in terms of the work done on the object. For example, if an object is lifted up to a certain height, work is done on the object. This results in an increase in energy of the object. The energy in the same object can decrease by the same amount, when the object falls back to its original position, doing 'work' in the process. This is a specific case of the law of conservation of energy since the work is done only by drawing energy from some other source. In the example given

above, the work is done by the muscles, which obtain their energy from the chemical reactions, transforming the food we eat into energy.

Another example is that when a spring is compressed, work is done on the spring which is stored in the spring as energy. When the spring is released, the same quantity of energy can be recovered as 'work' when it springs back to its original state.

MECHANICAL ENERGY

When a work is done on an object, then the object gains energy. The energy acquired by objects upon which work is done is known as mechanical energy.

When work is done on an object, then it can result in one of the following:

(i) Increase in speed. (Kinetic Energy)

(ii) Increase in height or state of strain. (Potential Energy)

For example, a book is lying on a table. If we apply a force on it and the book starts sliding on the table, then its speed has increased.

When a force is applied to lift an object, it results in an increase in height. When a force is applied to compress a spring it results in the decrease of spring's length. We call this as a state of strain and it is not the natural state.

KINETIC ENERGY

Moving objects can do work, hence they possess energy. For example, a moving block of wood colliding with a stationary block of wood can cause a displacement (and therefore 'work'). Hence, we can conclude that a moving object must hold energy.

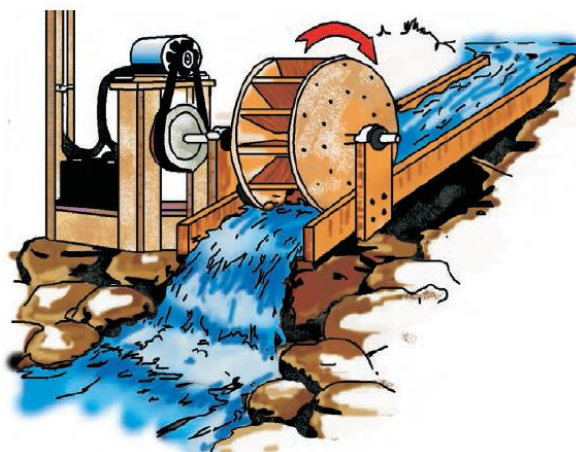
Energy possessed by an object due to its motion (or velocity) is called kinetic energy.

Here is another example of kinetic energy. The moving water which can rotate a wheel can be used to grind grain or to generate electricity.

A moving hammer can drive a nail into a wall or a piece of wood. Kinetic energy can be calculated using the formula $KE = \frac{1}{2} mv^2$ where 'm' is the mass of the moving body and 'v' is its velocity.

This formula can be derived using the equation of motion that you learnt earlier in this class.

Let us suppose that an object of mass 'm' is moving with a velocity 'v'. To bring it to rest, a force is required to act opposite to the direction of motion. The object will slow down and come to a halt. Let us suppose that the distance covered during the retardation is 's'.



The work done on the object is given by the formula:

$$W = F \times S \dots (1)$$

Using the formula $F = ma$ we can substitute 'F' in equation (1).

We get,

$$W = m \times a \times S \dots (2)$$

Using the equation of motion $v^2 = u^2 + 2as$, we can substitute 'a' in equation (2).

Since the initial velocity was v and the final velocity was zero we can substitute these values in equation (3). We get,

$$W = m \times \frac{(v^2 - u^2)}{2s} \times s \dots (3)$$

$$W = m \times \frac{(0^2 - v^2)}{2s} \times s$$

∴ We get

$$W = (-) \frac{1}{2} \times m \times v^2$$

Since this work, W , is done on the object, it must be stored in the object as energy. Notice that the work done by the external force is a negative quantity. The negative sign indicates that the object's energy has decreased, while slowing down to a halt. Therefore, the original value of the kinetic energy (KE) in the body, when it was moving must have been

$$= (+) \frac{1}{2} mv^2$$

which reduced to zero when it came to a halt. Hence KE of a moving body is given

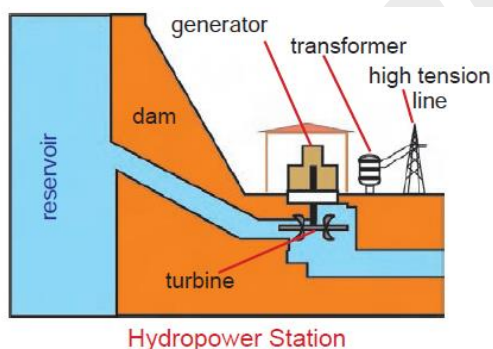
by the formula

$$KE = \frac{1}{2} mv^2$$

POTENTIAL ENERGY

The energy possessed by a body by virtue of its position or due to a state of strain, is called potential energy. Potential energy of an object raised through a height 'h' (gravitational potential energy) is calculated using the formula $PE = mgh$, where 'm' is the mass of the body, 'g' is the acceleration due to gravity and 'h' is the height through which the object has been raised.

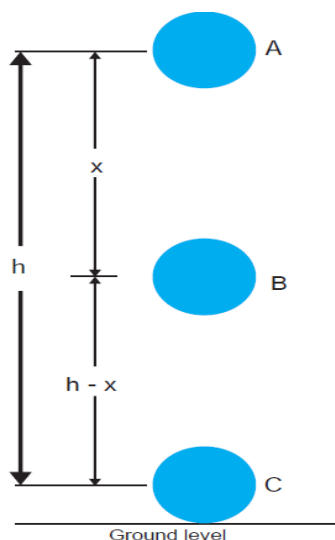
Example: Water stored in a reservoir has a large amount of potential energy due to which it can drive a water turbine when allowed to fall down. This is the principle of production of hydro-electric energy.



CONSERVATION OF MECHANICAL ENERGY

The law of conservation of energy is applicable to mechanical energy as well. Consider an object falling from a height 'h'. Assuming that all other forms of energy remain constant through the process (such as chemical energy, heat energy, sound energy, electrical energy, etc.) then mechanical energy should be conserved during every moment of the journey downwards.

This means that the sum total of the potential and kinetic energy at any point of the journey must be a constant. At the top, the potential energy is considerable. As the object falls freely, its potential energy keeps reducing (as the height reduces) and its kinetic energy keeps increasing (as the speed increases). Let us verify mathematically whether the total mechanical energy is constant, using the two formulae that we have learnt : $PE = mgh$ and $KE = \frac{1}{2} mv^2$.



Consider a body of mass ' m ' falling from a point 'A' which is at a height ' h ' from the ground as shown in the figure.

At 'A', at the instant of release its velocity is zero. At 'C', at the instant just before striking the ground its height is zero and its velocity maximum. At an intermediary point B, it has fallen through a height ' x ' and has acquired a certain velocity.

At A

$$PE = mgh$$

$$KE = 0$$

Total mechanical energy, $PE + KE = mgh$

At C

$$PE = 0$$

$$KE = \frac{1}{2} mv^2 = \frac{1}{2} m(2gh) = mgh \text{ [Using } v^2 = u^2 + 2as \text{ where } u = 0, a = g \text{ and } s = h]$$

Total mechanical energy, $PE + KE = mgh$

At B

$$PE = mg(h-x)$$

$$KE = \frac{1}{2} mv^2$$

$$= \frac{1}{2} m(2gx)$$

$$= mgx \text{ [Using } v^2 = u^2 + 2as \text{ where } u = 0, a = g \text{ and } s = x]$$

Total mechanical energy

$$= PE + KE$$

$$= mg(h-x) + mgx = mgh$$

Thus, we see that at each point of the journey, the total mechanical energy is constant. In other words, the total mechanical energy is conserved.