UNIT 5

Applied Chemistry

Learning Objectives

GBFE5M

After completing this lesson, students will able to:

- understand the various branches of applied chemistry.
- differentiate pure and applied chemistry.
- know latest technology of Nanochemistry.
- know the various types of drugs.
- understand the various uses of electrochemistry.
- understand the applications of radiochemistry.
- understand the various types of dyes and their application.
- acquire knowledge about food chemistry and agriculture chemistry.
- understand some basic ideas about forensic chemistry.

Introduction

We know that there are three major branches in chemistry namely: Organic chemistry, Inorganic chemistry and Physical chemistry. Organic chemistry deals with carbon and its compounds, inorganic chemistry is the study of minerals and the physical properties of these chemicals are dealt in physical chemistry. Then what is applied chemistry?

Food, medicines, cosmetics, dress materials and gold covering ornaments are some of the items used in our day to day life. They may differ in nature and applications. But all these are associated with chemistry. They are made of synthetic / natural chemicals or involve chemical principles and theories.

We face lot of difficulties in different means to lead our day to day life. Such difficulties make chemists to come out of new ideas and theories. For example, when people suffered by diseases, new chemical compounds were synthesized and used as drugs. New techniques were also developed to diagnose diseases. When farmers suffered due to low crop yield and pest- related problems in crop field, chemists developed new chemical fertilizers and pesticides to combat these issues. Thus chemical principles and theories are applied to various fields in order to achieve specific results or to solve real-world problems. This is called **applied chemistry.** In this lesson, let us discuss various branches of applied chemistry and their significance.

5.1 Nanochemistry

We know that the size and shape of materials influence their characteristics. Scientists found that materials having size about 1/1,000,000,000 metre show special characteristics. Then they started producing such kind of materials and studied the effect of size on properties. Thus a new branch of chemistry called 'Nanochemistry' was developed.

Nanochemistry is a branch of nanoscience, that deals with the chemical applications of nanomaterials in nanotechnology. It involves synthesis and manipulation of materials at atomic and molecular level and the study of their physical and chemical properties.

Nanotechnology is the application of science to manipulate matter to atomic or molecular scale and making use of them to develop specialized materials and devices for use in our day to day life. It deals with the materials which are smaller than 100 nanometres and hence it is so called.

5.1.1 Size of Nanoparticles

The word, Nano has been derived from the Greek word 'Nanos' which is designated to represent billionth fraction of a unit. For instance, 1 Nanometre = 1/ 1,000,000,000 metre. Can you imagine how small is a nanoparticle?

The following examples may help to illustrate how small the nanoscale is.

- One nanometre (nm) is 10^{-9} or 0.000,000,001 metre.
- A nanometre and a metre can be understood as the same size-difference as between golf ball and the Earth.
- Our nails grow 1 nm each second.
- The virus most usually responsible for the common cold has a diameter of 30 nm.
- One nanometre is about one twenty-five-thousandth the diameter of a human hair.
- A cell membrane is around 9 nm across.

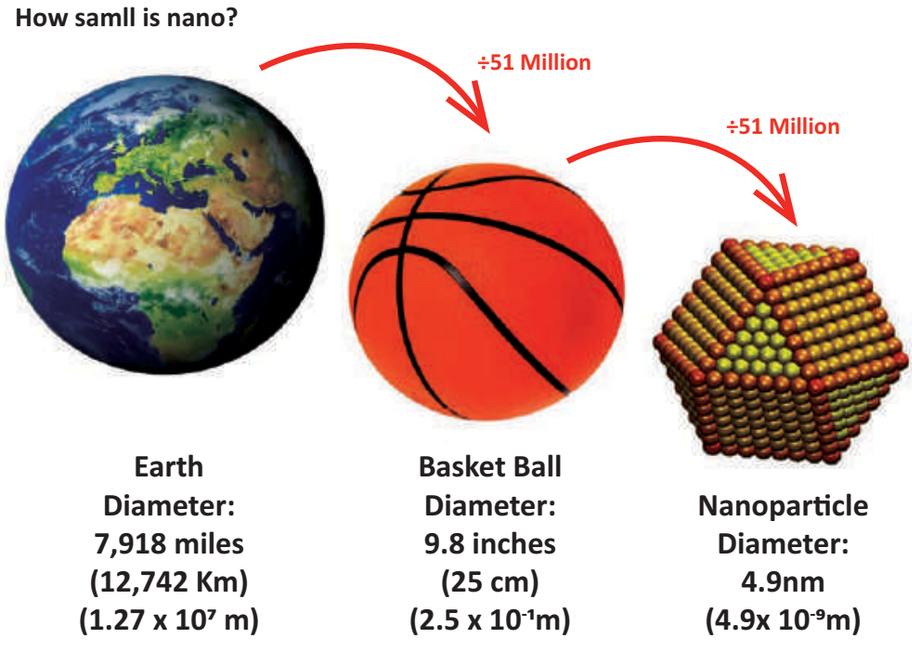


Figure 5.1 Comparisim of nanometre with metre

- The DNA double helix is 2 nm across.
- The diameter of one hydrogen atom is around 0.2 nm.

Activity 1

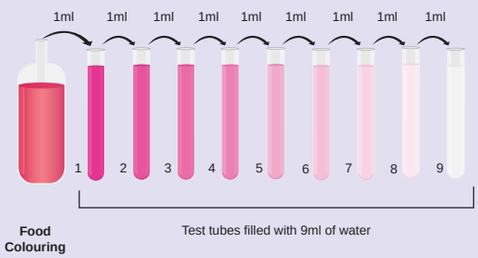
Let us try to understand the size at nanoscale through an example of Serial dilution.

Materials required:

Some scented food colouring materials, a Pasteur pipette, Nine test tubes, numbered 1-9.

Procedure

1. Fill each test tube carefully with 9 ml of water.
2. Using the Pasteur pipette, carefully add 1 ml of food colouring to Tube 1. Mix it thoroughly.
3. Smell the contents. What does it smell of? Does it smell the same as the original food colouring?
4. Now take 1 ml of liquid from Tube 1, add it to Tube 2 and mix thoroughly.
5. Continue the process by repeating steps 3 and 4: dilute Tube 2 into Tube 3, Tube 3 into Tube 4, and so on.



At what point you can no longer see any colour in the tubes?

At what point you can no longer smell anything in the tubes?

How can you explain the difference?

The method you have just used is called a **Serial dilution**. You can notice that in each tube, the food colouring is ten times more diluted than the previous tube. By the time they reach tube 9, the original food colouring would have been diluted to the level of one part of food colouring to a billion parts of water. At this stage, the intensity of colour and smell would be extremely low.

In such a way, when materials are broken down to nanoscale, they show some special surface properties which make them to be used for special kinds of applications. This type of manipulation of materials is done by nanotechnology.

How small is a nanoparticle? Visit the following link: https://www.youtube.com/watch?v=38Vi8Dm0kdY

Try it yourself

If you want to dilute 1 ml of the food dye to the same concentration as in Tube 9, in just one step, how much water would you need?

Figure 5.2 Nanometre sized changes

5.1.2 Properties of nanomaterials

Nanomaterials have the structural features in between those of atoms and the bulk materials. The properties of materials with nanometre dimensions are significantly different from those of atoms and bulk materials. This is mainly because the nanometre size of the materials render them, larger surface area, high surface energy, spatial confinement and reduced imperfections, which do not exist in the corresponding bulk materials. Due to their small dimensions, nanomaterials have extremely large surface area to volume ratio, resulting in more 'surface dependent' material properties. As the surface characteristics of nanoparticles are the main criteria to be considered for applications, highly sophisticated instruments like Scanning Electron Microscope (SEM), Tunneling Electron Microscope (TEM) and Atomic Force Microscope (AFM) are used to analyse the surface properties of a nanoparticle with high resolution.

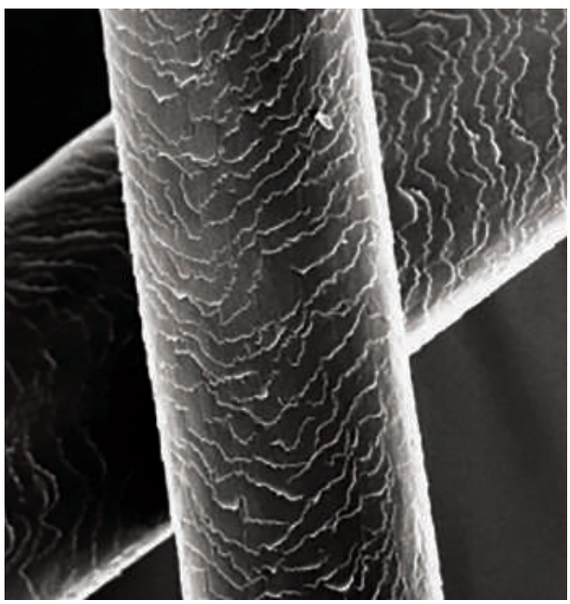


Figure 5.3 SEM image of human hair

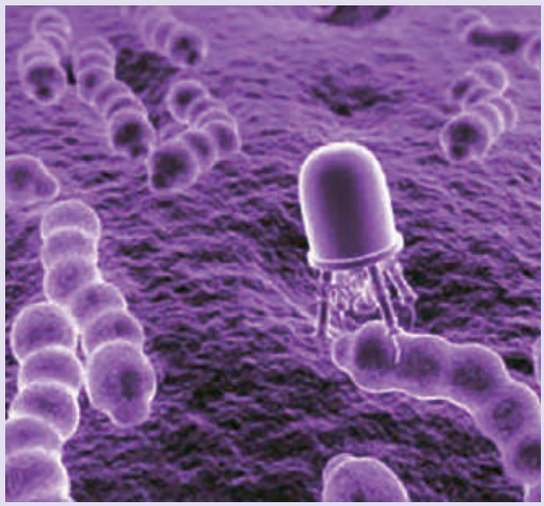
5.1.3 Applications of Nanochemistry

The range of commercial products available today is very broad, including stain-resistant and wrinkle-free textiles, cosmetics, sunscreens, electronics, paints and varnishes. Nanochemistry is applied in all these substance. Some of them are given below.

- The metallic nanoparticles can be used as very active catalysts.
- Chemical sensors from nanoparticles and nanowires enhance the sensitivity and sensor selectivity.
- Nano coatings and nanocomposites are found useful in making variety of products such as sports equipment, bicycles and automobiles etc.
- These are used as novel UV-blocking coatings on glass bottles which protect beverages from being damaged by sunlight.
- Nanotechnology is being applied in the production of synthetic skin and implant surgery.
- Nanomaterials that conduct electricity are being used in electronics as minute conductors to produce circuits for microchips.
- Nanomaterials have extensive applications in the preparation of cosmetics, deodorants and sun screen lotion and they are used to improve moisturizers without making them too oily.
- Nanoparticle substances are incorporated in fabrics to prevent the growth of bacteria.

- Biomedical devices like drug infusion pumps, microneedles and glucometer are made from nanomaterials.
- Nanochemistry is used in making space, defence and aeronautical devices

More to Know



Nanorobotics is an emerging branch of nanotechnology which involves creating machines or robots at nanoscale. These devices range from 0.1-10 micrometres and are made up of nano scale or molecular components. Nanorobots can be used in different application areas such as medicine and space technology. Nowadays, these nanorobots play a crucial role in the field of Bio-Medicine, particularly for the treatment of cancer, removal of kidney stones, elimination of defected parts in the DNA structure, and for some other treatments that need utmost support to save human lives. Nanorobots with embedded chemical biosensors are used for detecting the tumor cells in early stages of cancer development inside a patient's body.

Sunscreen lotion – Nanochemistry

Prolonged UV exposure causes skin-burns and cancer. Sun-screen lotions containing nano-TiO_2 provide enhanced sun protection factor (SPF). The added advantage of nano skin blocks such as ZnO and TiO_2 is that they protect the skin by sitting onto it rather than penetrating into the skin. Thus they block UV radiation effectively for prolonged duration. Additionally, they are transparent, thus retain natural skin colour while working better than conventional skin-lotions.

5.1.4 Drawbacks of nanomaterials in chemistry

- Nanoparticles are unstable when they contact with oxygen.
- Their exothermic combustion with oxygen can easily cause explosion.
- Because nanoparticles are highly reactive, they inherently interact with impurities as well.
- Nanomaterials are usually considered biologically harmful and toxic.
- It is difficulty to synthesis, isolate and apply them.
- There are no hard-and-fast safe disposal policies for nanomaterials.

5.2 Pharmaceutical chemistry

People always want to lead healthy life. But due to various reasons such as pollution, life style and natural calamities they are always prone to diseases. So they need to fight against diseases in order to lead healthy life. Do you know how our ancestors treated diseases? There is a long history of plants being used to treat various diseases. They figure in the records of early civilisations of Babylon, Egypt, India and China.

When modern organic chemistry evolved at the beginning of nineteenth century, chemists isolated various alkaloids like morphine, quinine and atropine from plants and used them for treatment of diseases. After 1860, many developments arose from synthesis of medicinally important chemicals and were used for treatment of numerous diseases.

When scientists started using synthetic chemicals as medicines, they started to analyse the effects of those chemicals in human and made necessary modifications. Then another new branch of chemistry was evolved. It is called **Pharmaceutical Chemistry.**

Pharmaceutical chemistry is the chemistry of drugs which utilizes the general laws of chemistry to study drugs. Pharmaceutical chemistry deals with the preparation of drugs and study of the chemical composition, nature, behavior, structure and influence of the drug in an organism, condition of their storage and the therapeutic uses of the drugs. Drug discovery is the core of pharmaceutical chemistry.

5.2.1 Drugs

Even though we use so many chemicals in our daily life, the chemicals used for treating diseases are termed as **drug.** The word drug is derived from the French word 'droque' which means a dry herb.

According to World Health Organisation, a drug is defined as follows: 'It is a substance or product that is used or intended to be used to modify or explore physiological systems or pathological states for the benefits of the recipient'.

Figure 5.4 Drug store

5.2.2 Characteristics of drugs

Can we use all chemicals as drugs? Definitely not. A drug must possess the following characteristics:

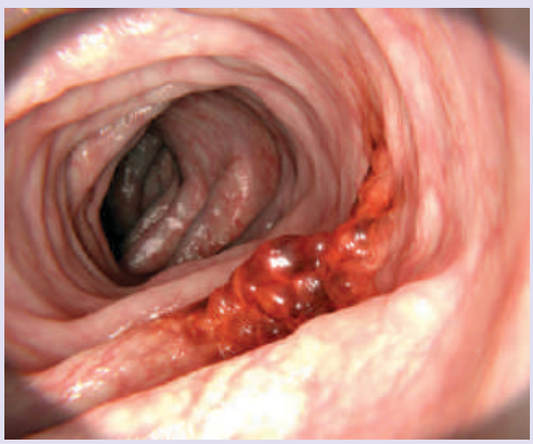
- It should not be toxic.
- It should not cause any side effects.
- It should not affect the receptor tissues.
- It should not affect the normal physiological activities.
- It should be effective in its action.

Chemicals which satisfy the above criteria only are preferred as drugs.

More to Know

Chemotherapy: Treatment of certain diseases by destroying the invading organism without damaging the cells of the host, by the use of certain organic compounds is known as **Chemotherapy.** It is widely used for treating cancer.

As part of the body's natural process, cells are constantly replaced through a process of dividing and growing. When cancer occurs, cells are reproduced in an uncontrolled manner. More and more cells are produced, and they start to occupy an increasing amount of space until they occupy the space previously inhabited by useful cells. Chemotherapy drugs interfere with the cancer cell's ability to divide and reproduce, and thereby prevent their growth. A single drug or a combination of drugs is used.



5.2.3 Sources of drugs

The main sources of drugs are animals and plants. The modern manufacturers adopt many chemical strategies to synthesize drugs for specialized treatments which are more uniform than natural materials**.** The following table shows various sources of drugs.

Table 5.1 Sources of drugs

Source or Process	Drug
Plants	Morphine, Quinine
Chemical Synthesis	Aspirin, Paracetamol
Animal	Insulin, Heparin
Minerals	Liquid Paraffin
Microorganism	Penicillin
Genetic Engineering	Human growth Hormone

5.2.4 Types of Drugs

Drugs fall into two general categories:

i) The drugs that are used in the treatment and cure of any specific disease.

ii) The drugs that have some characteristic effect on the animal organism, but do not have any remedial effect for a particular disease. This class includes, morphine, cocaine etc.

A. Anaesthetics

The drugs which cause loss of sensation are called **Anaesthetics.** They are given to patients when they undergo surgery.

(a) Types of Anaesthetics

When patients undergo a major surgery in internal organs, some anaesthetics are given so that the they lose sensation completely. But when they undergo a minor surgery in a specific part of the body, anaesthetic is given to loose sensation around that particular part. Based on this, there are two classes of anaesthetics as given below.

General anaesthetics: They are the agents, which bring about loss of all modalities of sensation, particularly pain along with 'reversible' loss of consciousness. For example, when a surgery is carried out on internal organs, this anaesthetics are given. The patient loses consciousness for specific period of time (depending on the duration of surgery) and get it back later.

Figure 5.5 General anaesthesia

Local anaesthetics: They prevent the pain sensation in localised areas without affecting the degree of consciousness. For example, dentist give patients this kind of anaesthetics when carry out a minor surgery in teeth.

Figure 5.6 Local anaesthesia

(b) Chemicals as Anaesthetics:

There are three major chemicals which are used as anaesthetics. They are:

Nitrous Oxide (N_2O): It is a colourless, non-irritating, inorganic gas. It is the safest of the anaesthetic agents. This is used after mixing general anaesthetics like ether.

Chloroform ($CHCl_3$): It is a volatile liquid. It has pleasant smell and sweet taste. With oxygen it forms a toxic carbonyl chloride. Hence it is not used now.

Ether: Diethyl ether or simply ether ($C_2H_5–O–C_2H_5$) is a volatile liquid. This is mixed with a stabilizer, 0.002% propyl halide. After absorption by tissues it attacks the central nervous system and makes the patient unconscious.

Discovery of anaesthesia

A young US dentist named William Morton inspired by the business opportunities afforded by technical advances in artificial teeth, searched for a way to relieve pain and boost dental profits. His efforts were soon rewarded. He discovered that when he or small animals inhaled sulfuric ether (now known as ethyl ether or simply ether) they became unresponsive. A few months after this discovery, on October 16, 1846, Morton anaesthetised a young male patient in a public demonstration at hospital.

The hospital's chief surgeon then removed a tumour on the left side of the jaw. This occurred without the patient apparently moving or complaining, much to the surgeon's and audience's surprise. So began the story of general anaesthesia, which for good reason is now widely regarded as one of the greatest discoveries of all time.

B. Analgesics

Analgesics are the compounds which relieve all sorts of pains without the loss of consciousness. These are also called as *pain killer*, or *pain relievers*. These are effective in headaches, myalgia and arthralgia.

Figure 5.7 Analgesics

Aspirin and Novalgin are the commonly used analgesics. Aspirin acts both as antipyretic as well as analgesic. Certain narcotics (which produce sleep and unconsciousness) are also used as analgesics. The analgesics are given either **orally or applied externally**. In general, externally applicable pain killers come as "gels".

Figure 5.8 Pain relieving gel

C. Antipyretics

Antipyretics are the compounds which are used for the purpose of reducing fever (lowering the body temperature to the normal). They are taken orally as tablets and capsules. The most common antipyretics are, aspirin, antipyrine, phenacetin, and paracetamol.

Figure 5.9 Antipyretics

D. Antiseptics

Antiseptic is a substance that prevents infections caused by disease causing microorganisms or pathogens. Anticeptics either kill the microorganism or prevent their growth. Anticeptics are used externally to cleanse wounds and internally to treat infections of the intestine and bladder.

- Iodoform (CHI_3) is used as an antiseptic and its 1% solution is a disinfectant.
- 0.2 percent solution of phenol acts as an antiseptic and its 1% solution is a disinfectant.
- Hydrogen peroxide is a minor antiseptic mainly used for cleansing wounds.

Figure 5.10 Antiseptics

E. Antimalarial

Malaria is a vector borne disease which causes shivering and fever. It raises the body temperature to 103-106°F. It causes **physical weakness** with the side-effects in liver and also causes **aneamia**.

Extracts of roots and stems of certain plants are extensively used as antimalarial. Quinine is a natural antimalarial obtained from Cinchona bark. The last antimalarial discovered in 1961 is pyrimethamine. However, quinine, primaquine and chloroquine are some of the best antimalarials. Chloroquine is used specially to control malarial parasites such as plasmodium ovale, plasmodium vivax etc. It is not used in curing the disease. It is used as an additive with other antimalarial drugs.

Figure 5.11 Cinchona Bark

F. Antibiotics

Many microorganisms (bacteria, fungi and molds) produce certain chemicals which inhibit the growth or metabolism of some other disease causing microorganism. Such chemical compounds are known as *antibiotics*. These need to be present only in low concentration to be effective in their antibiotic action. The first antibiotic 'penicillin' was discovered by Alexander Fleming in1929, from the mould Penicillium notatum. Penicillin is extensively used for rheumatic fever, narrowing of heart wall, bronchitis, and pneumonia etc.

The first commercially available antibacterial was developed in 1932. But mold and plant extracts were used to treat infections by ancient Egyptians and Greeks over 2,000 years ago. Penicillin wasn't actually discovered until 1928, but the ancient Egyptians had the practice of applying moldy bread to infected wounds for treatment. Penicillin was an important antibiotic back in 1941, when it became more popular, because it helped to treat battle wounds for soldiers. It was named as the 'miracle drug'.

More to Know

Alexander Fleming was a doctor and scientist in London, England, in the early 1900s who was trying to figure out how to kill bacteria. Back in those days, many people got sick and died from infections caused by bacteria. In his lab, Fleming was experimenting with bacteria when some of his experiments accidentally got a kind of mold in them called **Penicillium** (pronounced pen-ih-SILL-ee-um). He noticed that the bacteria wasn't growing around the mold and studied it more. Eventually, he separated out small amounts of 'mold juice,' which is now knows as **penicillin.** Although Fleming first recognized how well it could kill dangerous bacteria, he wasn't able to make enough of it to turn it into a life-saving medicine.

There are three main sources of antibiotics: (i) Bacteria (ii) Fungi and (iii) Actinomycetes. The original antibiotics, like a lot of today's antibiotics, are derived from natural sources. Certain plant extracts, essential oils, and even foods have antibiotic properties. Example: Honey, garlic, ginger, clove, neem and turmeric.

Figure 5.12 Sources of Antibiotics

G. Antacids

Quite often, after eating oily and spicy food, one may feel uncomfortable due to some burning sensation in stomach / food pipe. This is due to imbalance in the acidity in the stomach. Certain drug formulations provide relief from such burning sensation. These are known as **antacids.** Antacids are available in tablet as well as gel / syrup forms. These antacids contain magnesium and aluminium hydroxides, in addition to flavouring agents and colour.

Figure 5.13 Tablet form of antacids

Activity 2

Complete the following table by suggesting suitable type of drug(s) for the given health conditions.

Condition	Type of drug(s)
Ramu's grandfather suffers from knee pain.	
Sudha had spicy food last night and got indigestion.	
When Kavin returned home from school, he got wet in rain. So he suffered from fever.	
Nimmy cut her hand when sharpening her pencil.	

Try to learn: Ask your mother or grandmother, to suggest some home remedies for the fore said situations.

5.3 Electrochemistry

We use so many electronic devices like mobile phone, and electrical devices like torch light in our daily life. Electricity produced by the battery is the key factor which makes these devices to function. But how does battery produce electricity? Because it contains some chemicals in it. The chemical reactions (chemical energy) that take place in the battery produce electricity (electrical energy). So, when scientists realized that chemical energy can be converted into electrical energy and vice versa, another branch of applied chemistry was developed. It is **Electrochemistry.**

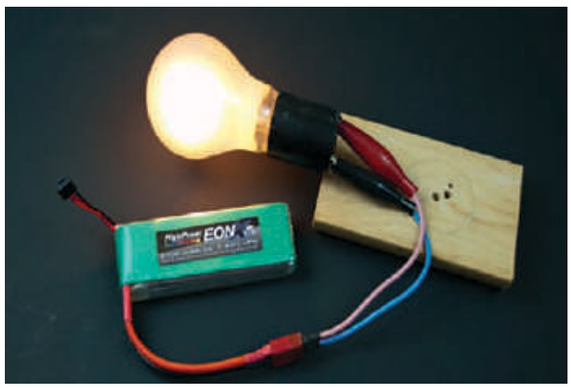


Figure 5.14 Battery-Source of Electric Energy

Thus **Electrochemistry** is a branch of chemistry which deals with the relation between electrical energy and chemical change. It is mainly concerned with the processes taking place between the electrode and solution having ions called **electrolyte**.

5.3.1 Electrochemical Cell

So many chemical reactions take place around us. Do all they produce electricity? No. Only redox reactions that take place in a specific device can produce electricity. The device that make use of a chemical change to produce electricity or electricity to produce chemical change is called **Electrochemical Cell.**

(a) Components of Electrochemical Cell

An electrochemical cell may comprise of the following two major components:

Electrode: It is a solid electrical conductor made of metal (sometimes non-metal like graphite). A cell consists of two electrodes. One is called **Anode** and the other is called **Cathode.**

Electrolyte: It is made up of solutions of ions or molten salts which can conduct electricity.

(b) Cell reactions

An electrochemical cell involves two reactions simultaneously.

Oxidation: As we know already, an oxidation is **loss of electron**. In electrochemical cells, oxidation takes place at anode.

Metal → Metal ion + electron (e^-)

Reduction: It involves gain of electron. Reduction takes place at cathode

Metal ion + electron (e^-) → Metal

Since both the reactions take place simultaneously, the inter conversion of electrical and chemical energy in electrochemical cells involves a **redox reaction.**

(c) Types of Electrochemical Cell

Based on the nature of the energy conversion, electrochemical cells are broadly classified as below.

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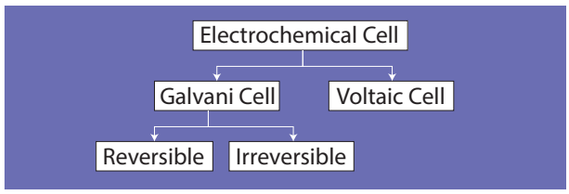


Galvanic Cell

- It is an electrochemical cell which converts chemical energy into electrical energy i.e. it produces electricity from chemical reactions.
- It consists of two half cells namely **anodic half-cell** and **cathodic half-cell.**
- In anodic half-cell, the anode is in contact with its electrolyte whereas in cathodic half-cell, the cathode is in contact with its electrolyte.
- The anode and cathode are connected by a conductor wire. The electrolytes of half-cells are connected through a tube containing a saturated salt solution. It is called **salt bridge**. Thus in galvanic cell, both the half-cells are kept separately but stay connected electrically.

How does a galvanic cell produce electricity?

At anode, oxidation takes place which releases electrons. These electrons are attracted by cathode and hence the electrons flowing from anode to cathode are gained in reduction reaction. As long as the redox reaction proceeds, there is a flow of electrons and hence electricity.

Daniel Cell

It is a type of galvanic cell in which zinc metal acts as anode and copper metal as cathode. Aqueous zinc sulphate solution makes the anodic electrolyte whereas aqueous copper sulphate solution makes the cathodic electrolyte. Saturated solution of potassium chloride (KCl) acts as salt bridge. The following figure depicts the construction of Daniel cell.

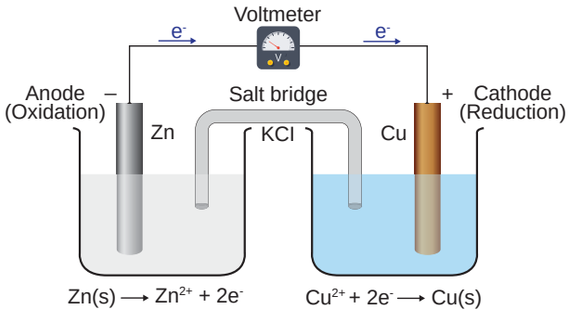


Figure 5.15 Daniel Cell

At anode, zinc undergoes oxidation losing its electrons.

$Zn_{(s)} \rightarrow Zn^{2+} + 2e^-$ (Oxidation)

At cathode, copper ions from cathodic electrolyte gain electrons at the surface of cathode and get reduced to copper metal.

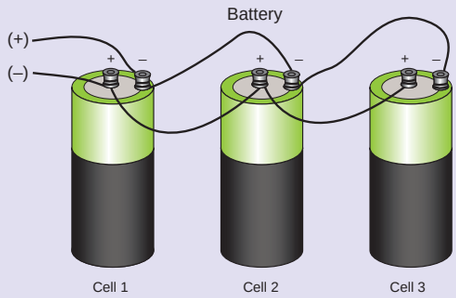
$Cu^{2+} + 2e^- \rightarrow Cu_{(s)}$ (Reduction)

Net reaction: $Zn_{(s)} + Cu^{2+} \rightarrow Zn^{2+} + Cu_{(s)}$

Cell potential of Daniel cell is 1.1 V

Are cell and battery same or different?

A cell is a **single unit** consisting of an anode, cathode and electrolyte. Battery is the combination of two or more cells connected in series.



Activity 3

With the help of your teacher, construct the galvanic cell using lemon and potato. Identity their anode, cathode and electrolyte.

Electrolytic Cell

- It is an electrochemical cell which converts electrical energy into chemical energy i.e. in electrolytic cells, electricity is used to bring about chemical reactions.
- Here, both anode and cathode are in contact with same electrolyte and thus the half-cells are not separated. As seen in galvanic cells, electrolytic cell also involves redox reaction.

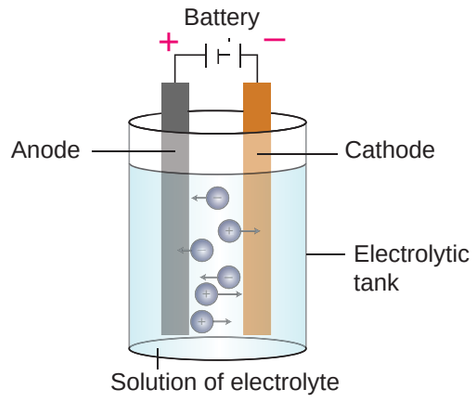


Figure 5.16 Electrolytic Cell

We get electricity from galvanic cells. But electrolytic cells use electricity. Then how are they useful?

In electrolytic cells, when electricity is passed to the electrolyte, it dissociates into its constituent ions. These ions undergo redox reaction forming the respective elements. This phenomenon is called **Electrolysis.** So electrolysis is a process by which an electrolyte is decomposed into its constituent elements by passing electricity through its aqueous solution or fused (molten) state.

(d) Applications of Electrolysis

Electrolysis has wide range of applications both in industry and research. The important applications are given below.

i. Electroplating

The process of depositing a thin layer of one metal over another metal by the process of electrolysis is called electroplating. Electroplating is one of the main processes applied in most of the industries. Some important applications of electroplating are given below.

Figure 5.17 Chromium plating on iron

Corrosion prevention: It is done to protect the metal from corrosion. For example, metals like iron are electroplated with tin, nickel or chromium to protect them from rusting.

Decoration: In some cases, electroplating is done to beautify the surface of a metal. For example, the metals like Au or Ag are deposited over metals like Cu to improve their beauty. Gold covering jewels are made by this method in which gold is electroplated over copper, silver or tin.

Figure 5.18 Gold Covering

Repairs: In some cases, broken parts of machinery may require electro- deposition of a metal between broken parts.

ii. Electro-refining of metals

It is a process of purifying metals by electrolysis. When metals of very high degree of purity are required, electro refining is done.

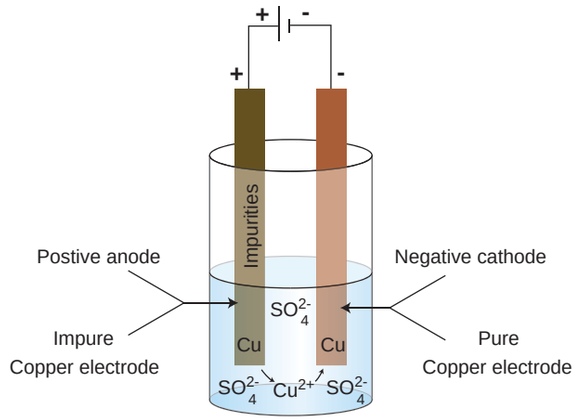


Figure 5.19 Electro-refining of Copper

iii. Electro manufacturing

Electro manufacturing is a process of manufacturing metals, non-metals and compounds by electrolysis. For example a number of metals like Na, Al, Mg, Ca, Cu, etc., non-metal molecules like H_2, O_2, F_2, Cl_2 and compounds like NaOH, $KClO_3$ etc have been manufactured by this method.

(e) Significance of electrochemistry

The subject of electro chemistry is of great significance. Some of its applications are given below.

i. It has been used to discover important technical processes for the production and purification of non-ferrous metals, and for the electro- synthesis of organic compounds.

ii. Electrochemistry has been used to predict whether a particular reaction will occur or not.

iii. The detection of alcohol in drunken drivers is possible through the electrochemical redox reaction of ethanol.

iv. Production of metals like aluminum and titanium from their ores involve electrochemical reactions.

v. Diabetes blood sugar metres measure the amount of glucose in the blood through its redox potential.

vi. Lead acid batteries, lithium-ion batteries and fuel cells are based on electrochemical cells. Fuel cell is used to bring about direct conversion of chemical energy into electrical energy.

5.4 Radiochemistry

You have studied in previous chapters that elements can exist in nature as their isotopes. Isotopes are atoms with the same number of protons and electrons, but a different number of neutrons. Some isotopes are stable and stay forever. These are the elements that we see around us and find in nature. However, some isotopes are unstable and they undergo disintegration by losing their energy in the form of radiation. As we studied earlier, every element tries to attain stability by sharing, losing or gaining electrons (octet rule). Thus the unstable isotopes of elements lose their energy in the form of radiation to become stable.

This phenomenon is called **radioactive decay**. The isotope which undergoes radioactive decay is called **radioactive isotope** or **radioisotope**. This property of isotopes is known as **radioactivity**.

Uranium in the ground can decay into radon gas which can be very dangerous to humans. It is thought to be the second leading isotope to cause lung cancer.

Radiochemistry is the study of chemistry of radioactive and non-radioactive isotopes. It includes both natural and artificial isotopes. Radiochemistry mainly deals with application of radioisotopes to study the nature of chemical reactions of non-radioactive isotopes of elements and applications of radioisotopes to various fields.

5.4.1 Applications of Radiochemistry

Radioisotopes can easily be detected and estimated quantitatively. So they are used in radiochemistry for various applications. Radiochemistry mainly deals with study of chemical reactions of non-radioactive isotopes using radioisotopes. In addition to that it could find applications in medical field and environmental management also. Let us list important applications of radioisotopes.

Radiocarbon dating: It is a method by which the age of fossil wood or animal is determined using C-14 isotope.

Study of chemical reactions: The nature of some of the chemical reactions can be studied by mixing a radioisotope with non-radioactive isotope of the reactants. The radioisotope used for this purpose is called **radiotracer**. For example, by photosynthesis plants synthesize carbohydrate from carbon dioxide and water as shown in the following reaction.

$$\underset{\text{Carbon dioxide}}{6CO_2} + \underset{\text{Water}}{6H_2O} \xrightarrow{\text{Light}} \underset{\text{Sugar}}{C_6H_{12}O_6} + \underset{\text{Oxygen}}{6O_2}$$

Here a question arises that whether the oxygen evolved in this process comes from CO_2 or H_2O. By using radioisotope O-18 as tracer, it was found that the evolved oxygen comes from H_2O.

Diagnosis: Radioisotopes are found very useful to diagnose and understanded many diseases.

Table 5.2 Radioisotope in Diagnosis

Radioisotope	Diagnosis used for
Iodine-131	Location and detection of brain tumor, thyroid gland disorder
Sodium-24	Location of blood clot and circulation disorders, pumping action of heart
Iron-59	Diagnosis of anaemia, pregnancy disorder
Cobalt-60	Diagnosis of cancer
Hydrogen-3	Water content of the human body

Henry Becquerel (France) was awarded Nobel prize for his discovery of spontaneous radioactivity in 1903. In the same year Pierre Curie (France) and Marie Curie (France) were awarded for their research on radiation phenomenon. In 1911, Marie Curie (France) was awarded Nobel prize for the discovery of radium and polonium, and the isolation of radium. They only coined the word Radioactivity. In 1938, Enrico Fermi (Italy) was awarded Nobel Prize for the discovery of nuclear reactions induced by slow neutrons.

Pierre Curie & Marie Curie

Radiotherapy: Radioactive isotopes are used in the treatment of many diseases. This kind treatment is called radiotherapy.

Table 5.3 Radioisotope in Treatment

Radioisotope	Treatment used for
Gold-198	Cancer
Iodine-131	Hyperthyroidism and cancer
Phosphorous -30	Blood disorder and skin disease
Cobalt-60	Cancer

5.5 Dye Chemistry

Human is always fascinated by colours, because we are living in a colourful world. We could see so many colours in plants and their flowers. We eat coloured food stuffs and use numerous coloured materials in our daily life. Do you know how do they get coloured? Because they contain some kind of chemicals in them which are called colourants.

Figure 5.20 Dye in various colours

The uses of colourants by mankind for painting and dyeing dates back to the dawn of civilization. Until the middle of the 19th century, all colourants applied were from natural origin. For example, inorganic pigments such as soot, manganese oxide, hematite were used as colourants. Organic natural colourants have also a timeless history of application, especially for colouring textiles.

Figure 5.21 Coloured Textiles

The organic compounds that are used as colourants are called **dyes**. These dyes are all aromatic compounds, originating from plants and also from insects, fungi and lichens.

After the evolution of modern organic chemistry, many kinds of synthetic dyes were prepared and used by mankind. **Dye chemistry** is the study of such kind of dyes. It provides us information on theory, structure, synthesis and applications of synthetic dyes.

DO YOU KNOW?

Synthetic dye manufacturing started in 1856, when the English Chemist **W. H. Perkin** in an attempt to synthesize quinine, obtained instead a bluish substance with excellent dyeing properties that was latter known as aniline purple, Tyrian purple or mauveine. Perkin patented his invention and set up a production line. In the beginning of the 20th century, synthetic dyestuffs had almost completely supplanted natural dyes. Now days, such substances are synthesized in factories through simple chemical reactions.

5.5.1 Colour and Structure of Dyes

Not all the aromatic compounds are coloured. Aromatic compounds which absorb light of wavelength range 350 nm – 700 nm (visible light) only are coloured. This nature of absorption of visible light by aromatic compound depends on their structure. The relationship between the colour of an organic compound and its structure was explained by a German scientist **Otto Witt (1876)** through the **Chromophore and Auxochrome theory**. You will study about this theory in your higher classes.

Activity 4

With the help of your teacher, try to find the answer for the following questions:

As the tomato ripens, its starts to change colour from green to yellow and then red at last. Why?

Why does a banana ripen, it turns from green to yellow?

Why does chilly change colour from green to yellow orange and then eventually red?

Why do all these colour changes follow same sequence i.e. green to yellow or orange or red?

5.5.2 Characteristics of Dyes

All coloured compounds are not dyes. Dyes are those coloured compounds which can be firmly fixed in fabrics by chemical or physical bonding.

So, a dye should have the following characteristics:

- It should have a suitable colour.
- It should be able to fix itself or be capable of being fixed to the fabric.
- It should be fast to light.
- It should be resistant to the action of water, dilute acids and alkalies.

More to Know

Many natural dyes have been known for a long time. These were obtained from vegetable sources.

Henna: It is one of the natural dyes. It is a reddish brown dye obtained from plant *Lawsonia inermis* (Tamil: Maruthondri). Paste of these leaves is used as a hair dye and also for colouring palms (Mehandhi).

Turmeric: It is the traditional natural cosmetic in India. It is obtained from the plant *Curcuma longa* (Manjal). It also acts as an antiseptic. Turmeric is mostly used in India for colouring food.

5.5.3 Classification of dyes

Now a days, practically all the dyes are synthetic, and are prepared from aromatic compounds obtained from coal tar. Therefore, such dyes are sometimes called as coal tar dyes. But they may differ in their basic structure and the way of application. So dyes are classified in two ways, one, based on the method of application and other on their parent structure.

(a) Based on method of application

Acid dyes: These are acidic in nature and used for dyeing animal fibres and synthetic fibres. These can be used for protein fibre such as wool and silk. E.g. Picric acid, Naphthol yellow-s

Basic dyes: These are basic dyes containing basic group ($-NH_2$,- NHR, - NR_2). They are used for dyeing animal fibres and plant fibres.

Mordant dyes or Indirect dyes: These dyes have a poor affinity for cotton fabrics and hence do not dye directly. They require pretreatment of the fibre with a mordant. Mordant (latin : mordere = to bite) is a substance which can be fixed to the fibre and then can be combined with the dye to form an insoluble complex called lake. Aluminium, chromium, and iron salts are widely used as mordants. E.g. alizarin.

Direct dyes: They have high affinity for cotton, rayon and other cellulose fibre. So they are applied directly as they fix firmly on the fabric. E.g. Congo red

Vat dyes: It can be used only on cotton and, not on silk and wool. This dyeing is a continuous process and is carried out in a large vessel called vat. So it is called as vat dye. E.g. Indigo

Figure 5.22 Vat dyes

(b) Based on Structure

Based on the structure, dyes are classified as below:

- Azo dyes
- Diphenyl methane dye
- Triphenyl methane dye
- Phthalein dye
- Anthraquinone dye
- Indigo dyes
- Phthalo cyanine dye
- Nitro and nitroso dyes

5.6 Agricultural and Food Chemistry

5.6.1 Agricultural Chemistry

Agricultural chemistry involves the application of chemical and biochemical knowledge to agricultural production, processing of raw materials into foods and beverages, and environmental monitoring and remediation. It deals with scientific relation between plants, animals, bacteria and environment.

(a) Role of agricultural chemistry

India is predominantly an agricultural country. Its major source of food production is agriculture. Indian agriculture began in 7000 BC and followed a traditional practice. After independence, rapid growth of population and urbanization made threats to agricultural production and it led to food scarcity.

Figure 5.23 Spraying pesticides

40% of today's global population works in agriculture, making it the single largest employment in the world.

Indian chemists and biochemists applied their knowledge and developed modernized agricultural practices which involve use of synthetic fertilizers, genetically modified crops, and equipments.

(b) Goals of agricultural chemistry

The goals of agricultural chemistry are to expand the understanding of the causes and effects of biochemical reactions related to plant and animal growth, to reveal opportunities for controlling those reactions, and to develop chemical products that will provide the desired assistance or control. It aims at producing sufficient nutritious food and feed the population in a sustainable way while being responsible stewards of our environment and ecosystem. Based on the issues and challenges in agricultural production, agricultural chemistry mainly focusses to achieve the following:

- Increase in crop yield and livestock
- Improvement of food quality
- Reducing cost of food production

(c) Applications of Agricultural Chemistry

Chemical principles and reactions are most widely used in agriculture in order to increase yield, to protect crops from diseases and to simplify the practice of agriculture. Various applications are give below.

Soil Testing: Crop lands may have different kinds of soil with varying pH. Soil pH is one of the main criteria to be considered for the selection of crop or remediation of soil. Soil testing involve determination of pH, porosity and texture.

Chemical Fertilizers: Fertilizers are chemical compounds added to crop field for supplying essential micro and macro nutrients required for crop growth. Ammonium nitrate, calcium phosphate, urea, NPK (Nitrogen, Phosphorous and Potassium), etc. are some of the fertilizers. Depending on the nature of soil, these fertilizers are used singly or as mixtures.

Figure 5.24 Chemical Fertilizers

More to Know

According to World Health Organization (WHO), "Pesticides are chemical compounds that are used to kill pests, including insects,

rodents, fungi and unwanted plants (weeds). Pesticides are used to kill vectors of disease, such as mosquitoes, and in agriculture, to kill pests that damage crops. By their nature, pesticides are potentially toxic to other organisms, including humans, and need to be used safely and disposed of properly."

Organic Farming: Even though chemical fertilizers and pesticides are used for plant growth and protection, they are harmful to human. So now a days, naturally prepared fertilizers and pesticides from herbs and microorganisms are used. This practice of agriculture is called Organic Farming. **Vermi compost** is one of such natural fertilizers produced from domestic wastes.

Pesticides and Insecticides: Crops are prone to diseases caused by pests and insects. Chemically synthesized pesticides and insecticides are used to solve these issues. Chlorinated hydrocarbons, organophosphates and carbamates are used as pesticides and insecticides.

5.6.2 Food Chemistry

Food is one of the basic needs of human and animal. The food we eat also are made of chemicals. Any human might require the following three kinds of food:

Body building foods: These are required for physical growth of body. E.g. Proteins

Energy giving foods: These the foods that supply energy for the functioning of parts human body. E.g. Carbohydrates

Protective foods: These protect us from deficiency diseases. E.g. Vitamins and Minerals

Every human requires all these three kind of foods in right proportion for the smooth functioning of the body. The diet that contain all these three foods in right proportion is called **Balanced diet**.

Food chemistry is chemistry of foods which involves the analysis, processing, packaging, and utilization of materials including bioenergy for food safety and quality.

(a) Goals of food chemistry

The main goal of food chemistry is to cater the needs of quality food to the population in a sustainable way. In basic research, food chemists study the properties of proteins, fats, starches, and carbohydrates, as well as micro components such as additives and flavourants, to determine how each works in a food system. In application research, they often develop new ways to use ingredients or new ingredients altogether, such as fat or sugar replacements.

(b) Chemicals in Food

Food we eat in our day to day life contains natural or synthetic chemicals. They serve different functions in human body.

Nutrients: They are the most essential chemicals present in food. They are required for the growth, physiological and metabolic activities of body. They are natural or synthetic. E.g. Carbohydrates, proteins, vitamins and minerals

Food additives: These are the chemicals added to food for specialized functions. The various types of additives of foods are given in Table 5.4.

Table 5.4 Food additives

Type of additive	Function of the additive	Example
Preservatives	They protect food from spoilage by microorganism in storage.	Vinegar, Sodium benzoate, benzoic acid, sodium nitrite
Colourants	They give pleasant colours to food	Carotenoids, Anthocyanin, Curcumin
Artificial Sweeteners	They add sweet taste to food	Saccharin, Cyclamate
Flavor enhancers	They are used to enhance the flavour of food items	Monosodium glutamate, Calcium diglutamate
Antioxidants	They prevent the oxidation of food. They protect us against cardiovascular disease.	Vitamin C, Vitamin E, Carotene

More to Know

There are several natural preservatives that you can use to preserve food.

Oil: When food comes into contact with air, it oxidises and starts to go bad. Oil slows down this oxidation process and keeps microorganisms from coming into contact with the food.

Common Salt: Microorganisms that spoil food tend to grow in water, but salt absorbs this water and prevents them from growing. Salt also prevents yeast and bacteria from decaying.

Sugar: Like salt, sugar also preserves food by absorbing the excess water and preventing microorganisms from growing. This is why jams, jellies and other fruits preserves don't go bad even after the jar has been opened. Sugar can even be added to the water in a flower vase – it feeds the flowers and keeps them from going bad.

Lemon juice: Lemon juice contains plenty of citric acid and ascorbic acid, also known as Vitamin C. Acidity prevents microorganisms from growing in the food and spoiling it. Vitamin C is also a powerful antioxidant that prevents food from oxidising.

Vinegar: Like lemon juice, vinegar is also extremely acidic, for it contains high amounts of acetic acid. Made of fermented sugar and water solutions, vinegar is commonly used to preserve pickles and canned foods, as it kills microbes and prevents the food from going bad.

Cloves: Cloves, have been used for thousands of years in Indian and Chinese medicines as a natural preservative. Containing high amounts of phenolic compounds, which have antioxidant properties, they keep food from going bad by preventing the growth of fungus and bacteria.

Cinnamon: Cinnamon, is an aromatic spice that is also used to preserve food. It does not protect food from all the bacteria and microbes that can decay it; it is more organism specific, meaning it kills only certain organisms.

Activity 5

With the help of your mother, know the food materials used in cooking. List out the chemicals present in them.

Food colouring or colour additives are pigments-synthetic or natural-added to food to create a certain colour, enhance a natural colour and improve the overall aesthetic appeal of a dish. Food colouring can make food fun. Food colouring contains one or more of the certified colour additives commonly known by their numbering system. Colour additives are blended to create a brightness or intensity to the base colour. The other basic ingredients of synthetic food colouring are propylparaben, propylene glycol and water.

Figure 5.25 Colour additives in cooldrinks

5.7 Forensic Chemistry

Forensic chemistry applies scientific principles, techniques, and methods to the investigation of crime. Our daily newspaper is carrying a lot of news on incidents of criminal activities such as robbery, murder, sexual harassment, etc. How the crime department investigate and analyse it? In real life the collection and analysis of evidence involve painstaking care and rigorous application of scientific principles.

Figure 5.26 Crime detection

5.7.1 Forensic Chemists in Criminal Investigation

In general, forensic chemists work in four steps in the investigation of crime.

Collection of Evidences: They collect physical evidences such as knife, instruments, materials, etc in a systematic way and uncover their information using chemistry.

Analysis of evidences: In criminal cases, chemists analyze substances such as blood and DNA to attempt to determine when and by whom the crime was committed.

Collaboration: To solve the crime, they discuss with other fellow investigators like police officers, detective and other forensic scientists.

Report of findings: Finally, they prepare a report of the conclusion of the analysis.

5.7.2 Method of Forensic Chemistry

The world of forensic chemistry, focusing on the theory and processes of chemistry in forensic analysis shows the role that chemistry plays in criminal investigations. The following are some methods used in crime investigation by a forensic chemitry lab.

Finger print: Finger print is one of the most important evidences in crime investigation. Fingerprints on smooth surfaces can often be made visible by the application of light or dark powder, but fingerprints on cheque or other documents are often occult (hidden). Occult fingerprints are sometimes made visible by the use of ninhydrin, which turns purple due to reaction with amino acids present in perspiration. Fingerprints or other marks are

also sometimes made visible by exposure to high-powered laser light. Cyanoacrylate ester fumes from glue are used with fluorescent dyes to make the fingerprints visible.

Figure 5.27 Finger print

Biometrics: The science that involves the study and analysis of human body prints is known as **biometrics**. The biometric system compares the body prints to the specimen data stored in the system to verify the identity of a person.

Figure 5.28 Biometrics

Activity 6

Find out the foot print of animals from the following:

DO YOU KNOW?

No two fingerprints are exactly alike! The ridges on your fingers start forming when you are still inside your mother's womb. Our fingers have sweat glands that ooze some oils and salt through tiny pores on the finger surface. This sticky film of sweat and oil trapped in the ridges leaves behind a print when we touch anything. It is difficult to get fingerprints on carpets and clothes as they absorb the oils. Just like fingerprints, our retinal print and tongue prints are also unique and cannot be forged by anyone. It is for this reason that these unique characteristics of the human body are used for authentication of a person's identity.

Alcohol test: Drinkers can be easily identified by the use of applied chemistry. The person being tested blows through a tube, which bubbles the breath through a solution of chemicals containing sulfuric acid, potassium dichromate, water, and silver nitrate. Oxidation of the alcohol results in the reduction of dichromate to chromic ion, with a corresponding change in colour from orange to green. An electrical device employing a photocell compares the colour of the test solution with a standard solution, giving a quantitative determination of the alcohol content. The test provides a quick and reproducible determination of the amount of alcohol in a person's breath and is a numerical measure of the amount of alcohol in the bloodstream.

Figure 5.29 Alcohol test

Forensic Toxicology: Toxicologists examine a wide range of materials such as blood stains, urine, and blood gases for traces of poisons or drugs. Even tiny samples of blood, saliva, or semen may be separated and subjected to enzymatic analysis.

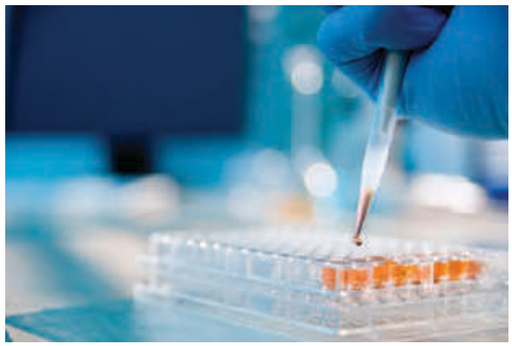


Figure 5.30 Forensic Toxicology

5.8 Applications of Applied Chemistry

- Many of the advantages of applied chemistry are around us. It is inevitable.
- Applied chemistry has given us innumerous synthetic materials to lead our day to day life.
- The applied chemistry makes a most important contribution to our society.
- It makes a major contribution to the country's economic development, and plays vital role worldwide.
- The products of applied chemistry are so widespread that they are used in our daily.

Points to Remember

- ❖ Nanochemistry is a branch of nanoscience, that deals with the chemical applications of nanomaterials in nanotechnology.

  1 Nanometre = 1/ 1,000,000,000 metre.

- ❖ Pharmaceutical chemistry deals with the preparation of drugs and study of the chemical composition, nature, behavior, structure and influence of the drug in an organism.
- ❖ Drug is a substance or product that is used or intended to be used to modify or explore physiological systems or pathological states for the benefits of the recipient.
- ❖ Electrochemistry is a branch of chemistry which deals with the relation between electrical energy and chemical change.
- ❖ Galvanic cell is an electrochemical cell which converts chemical energy into electrical energy .
- ❖ Radiochemistry is the study of chemistry of radioactive and non-radioactive isotopes.
- ❖ Dye chemistry is the study of dyes. It provides us information on theory, structure, synthesis and applications of synthetic dyes.
- ❖ Dyes are those coloured compounds which can be firmly fixed to fabrics by chemical or physical bonding.
- ❖ Agricultural chemistry involves the application of chemical and biochemical knowledge to agricultural production, the processing of raw products into foods and beverages, and environmental monitoring and remediation
- ❖ Food chemistry is chemistry of foods which involves the analysis, processing, packaging, and utilization of materials including bioenergy for food safety and quality.
- ❖ Forensic chemistry applies scienctific principles, techniques, and methods to the investigation of crime.

GLOSSARY

Anaesthetics	The drugs which cause loss of sensation.
Antipyretics	The compounds which are used for the purpose of reducing fever (lowering the body temperature to the normal).
Antiseptic	It is the substance that prevents infections caused by disease causing microorganisms or pathogens.
Antibiotics	It is a chemical compounds which was produced by many microorganisms (bacteria, fungi and moulds) which inhibit the growth or metabolism of some other disease causing microorganism.
Antacids	These are certain drug formulations which provide relief from burning sensation.
Balanced diet	The diet that contain all foods in right proportion.
Chemotherapy	Treatment of certain diseases by destroying the invading organism without damaging the cells of the host, by the use of certain organic compounds.
Drug	The chemicals used for treating diseases
Electrochemical Cell	The device that make use of a chemical change to produce electricity or electricity to produce chemical change.
Electrolyte	It is made up of solutions of ions or molten salts which can conduct electricity
Nanotechnology	It involves synthesis and manipulation of materials at atomic and molecular level and study of their physical and chemical properties.
Pharmaceutical Chemistry	It is the study of drugs and it involves drug development.

TEXTBOOK EVALUATION

GBY68X

I. Choose the correct answer.

1. One Nanometre is
   (a) 10^{-7} metre (b) 10^{-8} metre
   (c) 10^{-6} metre (d) 10^{-9} metre
2. The antibiotic Penicillin is obtained from _____
   (a) plant (b) microorganism
   (c) animal (d) sunlight
3. 1% solution of Iodoform is used as
   (a) antipyretic (b) antimalarial
   (c) antiseptic (d) antacid
4. The cathode of an electrochemical reaction involves _____
   (a) oxidation (b) reduction
   (c) neutralisation (d) catenation

5. The age of a dead animal can be determined by using an isotope of _____
   (a) carbon (b) iodine
   (c) phosphorous (d) oxygen
6. Which of the following does not contain natural dyes?
   (a) Potato (b) Beetroot
   (c) Carrot (d) Turmeric
7. This type of food protect us from deficiency diseases.
   (a) Carbohydrates (b) Vitamins
   (c) Proteins (d) Fats
8. Radiochemistry deals with
   (a) oxidants (b) batteries
   (c) isotopes (d) nanoparticles
9. The groups responsible for the colour of an organic compound is called
   (a) isotopes (b) auxochrome
   (c) chromogen (d) chromophore
10. Chlorinated hydrocarbons are used as
    (a) fertilizers (b) pesticides
    (c) food colourants (d) preservatives

II. Fill in the blanks.

1. _____ is an electrochemical cell which converts electrical energy into chemical change(Reaction).
2. Painkiller drugs are called _____
3. Aspirin is an _____
4. _____, _____ and _____ are macronutrients required for plant growth.
5. _____ is a chemical used in finger print analysis.

III. Match the following.

Antipyretics	-	Large surface area
Corrosion prevention	-	Iodine-131
Hyperthyroidism	-	Fever
Nanoparticle	-	Cancer cell identification
Nanorobotics	-	Electroplating

IV. Answer in brief.

1. What is Chemotherapy?
2. What are called Anaesthetics? How are they classified?
3. What is the need for chemical fertilizers in crop fields?
4. What is Forensic chemistry related to?

V. Answer in detail.

1. Draw the cell diagram of Daniel cell. Give its reactions.
2. Explain the types of dyes based on their method of application.
3. Name various food additives and explain their functions.

VI. HOTS

1. Batteries that are used in mobile phone can be recharged. Likewise, can you recharge the batteries used in watches? Justify your answer.
2. Sudha met with a fire accident. What kind of drug(s), she must take?
3. The soil pH of a crop land is 5. What kind of fertilizers should be used in that land?

REFERENCE BOOKS

1. Nanomaterials and Nanochemistry by Catherine Brechignac
2. Nuclear and Radiochemistry – Fundamentals and applications by Karl Heinrich Lieser
3. Food Chemistry (Third Edition) by Owen Fennema

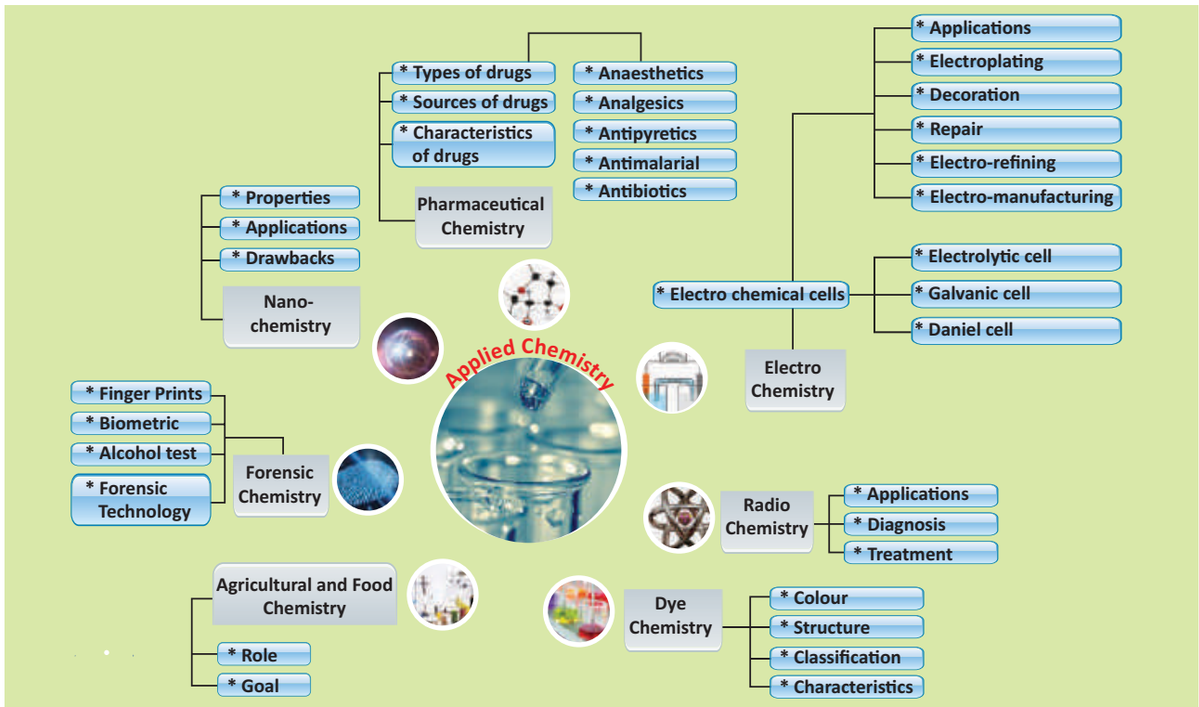
INTERNET RESOURCES

https://en.wikipedia.org/wiki/Agricultural_chemistry

https://www.medicalnewstoday.com/articles/321108.php

https://www.youtube.com/watch?v=kC1aPOqoYWc

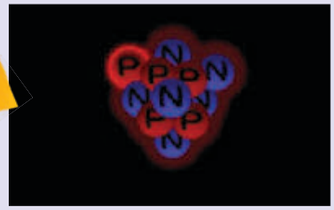
Concept Map



ICT CORNER

Applied Chemistry

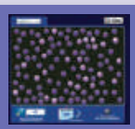
Experiment with radioactive elements to know about its half-life



Steps

- Use the given URL to open the simulation page and allow the "javascript" to play, if asks. Read the given description on how to perform the half-life simulation.
- Click the "Years Passed" button to increase the years by 1000 and press "Count the Remaining Atom" to know how much of the atoms have become "Daughter atoms".
- Use the "Table/Graph" button situated below the description to record your observations.
- Press the "video" button to view the process of degradation of radioactive atoms and its calculation


Step1


Step2


Step3


Step4

Radioactive Atoms Half-Life

URL: http://www.glencoe.com/sites/common_assets/science/virtual_labs/E18/E18.html

*Pictures are indicative only

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