Toppersnotes®
Unleash the topper in you

AFCAT

Air Force Common Admission Test

Indian Air Force

Volume - 3

General Science

SIERRA INNOVATIONS

INDEX

1 CHAPTER General Science

Branches and Instruments of Science

Branches of Science

Field of Study	Subject of Study
Acrobatics	A branch of exercise-related science
Entomology	Study of insects
Apiculture	Study of beekeeping
Epigraphy	Study of inscriptions
Aeronautics	Branch of science related to aircraft
Acoustics	Branch of science related to sound
Astronomy	Study of celestial bodies
Anthology	Study of flowers
Astrology	Study of the influence of planets and stars on humans
Astronautics	Science related to spacecraft
Arboriculture	Branch of science related to tree cultivation and production
Archaeology	Branch of science related to the study of ancient remains and human history
Orthopedics	Study and treatment of bones
Ornithology	Study of birds
Optics	Study of the nature and properties of light
Oliviculture	Study of olive cultivation
Osteology	Study of bones
Olericulture	Commercial cultivation of vegetables
Odontology	Study of teeth and gums
Oneirology	Study of dreams
Biochemistry	Branch of science dealing with chemical processes in living organisms
Arboriculture	Branch of science related to trees
Ecology	Study of the interrelationship between organisms and their environment
Ethology	Study of animal behavior
Cardiology	Study of the structure and functioning of the heart and blood circulation
Chemotherapy	Treatment of cancer using chemical compounds
Cryogenics	Study of properties of materials and phenomena at very low temperatures
Callology	Study of human beauty
Cosmology	Study of the origin, evolution, and eventual fate of the universe
Genetics	Study of the process of inheritance of genetic traits in organisms from one generation to another
Tribology	Study of friction and lubrication
Numismatics	Study of ancient coins
Neurology	Study of the nervous system
Numerology	Study of numbers
Pedology	Study of soil
Pathology	Study of the nature of diseases

Pisciculture	Study of the commercial production of fish
Pomology	Study of fruits
Parazoology	Study of sponges
Physiography	Study of physical geography
Floriculture	Cultivation of flowers
Phycology	Study of algae
Mycology	Study of fungi
Mineralogy	Study of minerals
Meteorology	Study of the atmosphere and related phenomena
Morphology	Study of the form and structure of organisms
Mammalogy	Study of mammals
Mammography	Branch of medical science dealing with examination of women's breasts
Mariculture	Production and cultivation of marine organisms
Molecular Biology	Study of the structure and functions of organisms at the molecular level
Lithology	Study of rocks and stones
Viticulture	Cultivation of grapes
Cytogenetics	Study of cells and their genetic characteristics
Cytology	Study of cells
Seismology	Study of earthquakes
Sericulture	Study of silk production
Psychology	Study of the human mind and behavior
Sorology	Study of lizards
Silviculture	Study of forest cultivation and management
Heliology	Study of the Sun
Hydropathy	Method of treating diseases using water
Horticulture	Study of growing fruits, flowers, vegetables, gardening, and flower production
Holography	A scientific method of creating three-dimensional images using laser beams
Hematology	Study of blood and related subjects
Hypnology	Study of sleep and related phenomena
Histology	Study of tissues
Ophiology	Study of snakes
Hepatology	Study of the gall bladder
Herpetology	Study of reptiles
Palynology	Study of plant pollen, spores, and certain microscopic planktonic organisms, in both, living and fossil form.
Demography	study of the size, territorial distribution and composition of population and how population changes over time due to births, deaths, migration and ageing

Important Points:

- 'Vertical farming' is a greenhouse method of agriculture where commercially viable crops are cultivated inside multi-storeyed buildings in cities using advanced greenhouse technology such as hydroponics and aeroponics.
- 'Silviculture' is the care and cultivation of wildlands.

Major Scientific Instruments and Their Uses

Name of Scientific Instrument	Use
Altimeter	An instrument used to measure altitude; commonly used in aircraft.
Anemometer	Measures wind speed and force; also indicates wind direction.
Audiometer	Measures the intensity of sound and is used for hearing tests.
Aerometer	Instrument used to measure the density of air and gases.
Actinometer	Measures the intensity of electromagnetic radiation.
Accumulator	A secondary cell battery used to store and supply electrical energy.
Anti-Aircraft Gun	A gun used to shoot down aircraft by firing shells.
Audiophone	A hearing aid device used to assist people with hearing difficulties.
Barograph	Measures changes in atmospheric pressure and records them in graphical form.
Barometer	Instrument used to measure atmospheric pressure.
Binocular	Instrument used to view distant objects.
Calipers	Used to measure internal and external diameters of cylindrical objects and thickness.
Calorimeter	Used to measure the quantity of heat.
Carburetor	Used in internal combustion petrol engines to mix air and fuel.
Cinematograph	Used to project motion pictures on a screen in sequence.
Commutator	Used to change the direction of electric current in a circuit.
Cyclotron	Instrument used to measure electrical power and to produce artificial conditions (as mentioned).
Dynamometer	Used to measure force or power.
Dictaphone	Used to record and reproduce spoken messages.
Fathometer	Instrument used to measure the depth of the sea.
Geiger–Müller Counter	Used to detect and measure radiation from radioactive sources.
Gravimeter	Instrument used to detect the presence of oil on the water surface.
Gyroscope	Used to measure or maintain the orientation and motion of rotating objects.
Hydrometer	Used to measure the relative density of liquids.
Hydrophone	Used to detect and measure sound waves underwater.
Hygroscope	Instrument used to indicate changes in atmospheric humidity.
Kymograph	Used to record graphs of physiological movements such as blood pressure and heartbeat.
Lactometer	Instrument used to check the purity of milk. It measures the relative density of milk to determine the presence of added water.
Pressure Gauge (Manometer)	Used to measure the pressure of gases.
Machmeter	Instrument used to measure the speed of air in terms of the speed of sound (Mach number).
Magnetometer	Used to compare magnetic moments and measure magnetic fields.
Microphone	Converts sound waves into electrical signals.
Odometer / Speedometer	Used to measure the speed of a motor vehicle.
Periscope	Used in submarines to observe the surface while remaining underwater, allowing observation of external activities without obstruction.
Pyrometer	Instrument used to measure very high temperatures, such as the temperature of the Sun.

Polygraph	Used as a lie detector; records several physiological changes simultaneously such as heartbeat, blood pressure, and respiration.
Radar	Used to determine the direction and distance of approaching aircraft using radio waves.
Radiator	Device used to cool the engines of motor vehicles.
Radiometer	Measures the intensity of radiant energy.
Seismograph	Records and graphs the intensity of earthquakes occurring on the Earth's surface.
Spectrometer	Used to study different spectra and measure wavelengths of different colours.
Sphygmomanometer	Used to measure blood pressure in human arteries.
Transformer	Used to increase or decrease the voltage of alternating current (AC).
Telemeter	Instrument used to measure and record physical events occurring at distant locations.
Tachometer	Instrument used during surveying to measure distance, elevation, etc.
Transponder	Receives a signal and immediately transmits a response signal.
Ultrasonoscope	Measures and utilizes ultrasonic sound; used in detecting brain tumors and identifying heart defects.
Venturimeter	Instrument used to measure the rate of flow of fluids.

Important Invention and Discoveries

Important Inventions / Discoveries / Laws and Their Scientists

Invention / Discovery / Law / Theory	**Scientist / Inventor / Proponent**
Theory of Evolution	Charles Darwin
Radio Telegraphy	Guglielmo Marconi
Atomic Structure	Niels Bohr & Ernest Rutherford
Modern Atomic Theory (discovered that each chemical element is made up of a unique type of atom and that atoms differ by their mass)	John Dalton
Radium	Marie Curie & Pierre Curie
Radioactivity	Henri Becquerel
Mechanical Television	J. L. Baird
Periodic Table	Dmitri Mendeleev
Electron	J. J. Thomson
Proton	Discovery – E. Goldstein; Naming – Rutherford
Neutron	James Chadwick
Electronic Television	Philo T. Farnsworth
Braille Script (for the visually impaired)	Louis Braille
Genetics	Gregor Johann Mendel
Lightning Conductor	Benjamin Franklin
Photoelectric Effect	Albert Einstein
Law of Gravitation	Isaac Newton
Laws of Motion	Isaac Newton
Quantum Theory	Max Planck
Solar System (Heliocentric Theory)	Nicolaus Copernicus
Laws of Planetary Motion	Johannes Kepler
Raman Effect	C. V. Raman

Telephone	Alexander Graham Bell
Gramophone	Thomas Alva Edison
Electric Bulb	Thomas Alva Edison
Bicycle	Kirkpatrick Macmillan
Motorcycle	Gottlieb Daimler
Revolver	Samuel Colt
Microphone	Alexander Graham Bell
X-rays	Wilhelm Conrad Röntgen
Thermos Flask	James Dewar
Mechanical Lift	Elisha Graves Otis
Nuclear Reactor	Enrico Fermi
Safety Lamp	Humphry Davy
Positron	Carl Anderson
Dynamo	Michael Faraday
Transistor	William Shockley, John Bardeen & Walter Brattain
Dynamite	Alfred Nobel
Cosmic Rays	Victor F. Hess
Theory of superconductivity	John Bardeen
Wave nature of matter	Louis Victor de Broglie
Transformer	Michael Faraday
Penicillin	Alexander Fleming
Barometer	Evangelista Torricelli
Insulin	F. G. Banting
Radar	Robert Watson-Watt
pH Scale	Søren Sørensen
Fountain Pen	L. E. Waterman

Aeroplane	Wright Brothers (Orville & Wilbur Wright)
Theory of Relativity	Albert Einstein
Blood Groups	Karl Landsteiner
Blood Circulation System	William Harvey
Ohm's Law	Georg Simon Ohm (Germany)
For Invention of mercury barometer	Evangelista Torricelli
Microwave Oven	Percy Spencer
Vernier scale	Pierre Vernier
Vernier scale	William Stanley
battery	Alessandro Volta
Ammeter	Friedrich Drexle
Animation	Emile Reynaud
discovered the composition of water	Herbert C Brown

Famous Medical Inventions and Discoveries

Discovery / Invention	**Scientist / Discoverer**
Smallpox Vaccine	Edward Jenner
Tuberculosis Bacterium	Robert Koch
Penicillin	Alexander Fleming
Bacteria	Antonie van Leeuwenhoek
Antigen	Karl Landsteiner
Chloroform	James Young Simpson
Polio Vaccine (Injectable)	Jonas E. Salk
Discovery of Polio Virus	Karl Landsteiner & Erwin Popper
Polio Oral Drops Vaccine	Albert Bruce Sabin
Malaria Parasite & Treatment	Ronald Ross

Diabetes (Research & Treatment)	Banting
Blood Circulation	William Harvey
Vitamin hypothesis	Casimir Funk
Sulpha Drugs	Domagk
Heart Transplantation	Christiaan Barnard
Insulin	Frederick Grant Banting
Anti-Rabies Vaccine	Louis Pasteur
Antiseptic Surgery	Joseph Lister
First Test-Tube Baby	Robert Edwards & Patrick Steptoe
X-Rays	Wilhelm Conrad Röntgen
Stethoscope	René Laennec

Homeopathy	Samuel Hahnemann
Contraceptive Pills	Gregory Pincus
BCG Vaccine	Calmette & Guérin
Leprosy (Hansen's Disease)	Gerhard Armauer Hansen
ECG (Electrocardiography) Machine	Willem Einthoven
Red Blood Cells (RBC)	Antonie van Leeuwenhoek
White Blood Cells (WBC)	William Addison & Andral
Blood Groups	Karl Landsteiner
Open Heart Surgery	Walton Lillehei
Cell	Robert Hooke

Inventions and Discoveries

S. No.	Invention / Discovery	Person / Institution	Year / Additional Details
1	Electrokinetic streaming potential for energy harvesting	IIT Guwahati	Energy harvesting technology
2	Country's first indigenously designed standing wheelchair 'ARISE'	IIT Madras	Assistive mobility device
3	Platinum as a catalyst (first observation)	Johann Wolfgang Döbereiner	Foundation of catalysis
4	Emojis introduced internationally on mobile devices	Apple	Popularized global emoji usage
5	iPad as a multimedia device	Apple	Introduced in 2010
6	Study of past climate using tree rings (Dendroclimatology)	Scientific discipline	Climate reconstruction method
7	3D optical data storage	—	Data stored in multiple layers of optical disc
8	Hybrid Hard Disk Drive	—	HDD combined with flash memory (≥128 MB cache)
9	Whole Disk Encryption	—	Encrypts data before storage
10	Facebook	Mark Zuckerberg	Social networking platform
11	Kelvin temperature scale & codification of thermodynamics laws	William Thomson (Lord Kelvin)	Absolute zero = −273.15°C
12	Isolation of methane gas	Alessandro Volta	Methane explosion using electric spark
13	FORTRAN (first high-level programming language)	John Backus	Developed in 1957
14	Dolly (first cloned living being)	Roslin Institute, Scotland	Species: Sheep
15	Pascal's Law	Blaise Pascal	1653
16	Fifth star in the Trapezium (Orion)	Robert Hooke	1664
17	Artificial synthesis of urea	Friedrich Wöhler	1828
18	Michelson–Morley Experiment	A.A. Michelson & E.W. Morley	1887

19	VSEPR theory redefined	Nyholm & Gillespie	1957
20	First Bose–Einstein Condensate	Eric Cornell & Carl Wieman	1995
21	Discovery of four moons of Jupiter	Galileo Galilei	Early 1610
22	Bose–Einstein Condensate in space	ISS Experiment	July 2018
23	Microlattice metal	—	Lighter than air, stronger than steel

Important Compound and Their Uses

Sodium Chloride (NaCl):

- **Source:** Hydrochloric acid + Sodium hydroxide
- It is commonly known as table salt or kitchen salt.
- It is used in pickling, preservation of meat and fish, removal of ice, and in the manufacture of other compounds (NaOH, bleaching powder, etc.).

Sodium Hydroxide (NaOH):

- It is called **caustic soda.**
- Sodium hydroxide is prepared by the chlor-alkali process. In this process, brine (sodium chloride solution) is electrolyzed to produce chlorine gas, hydrogen gas, and sodium hydroxide.
- Due to its corrosive nature, it is also called lye.
- It is used as a cleaning agent, in washing soda preparation, pulp and paper manufacturing, textile industry (synthetic fiber production), aluminium extraction, petroleum products manufacturing, and food preservation.

Sodium Carbonate Decahydrate ($Na_2CO_3 \cdot 10H_2O$):

- It is known as **washing soda.**
- It is a hydrated form of sodium carbonate containing 10 molecules of water of crystallization.
- It is alkaline in nature and is a basic salt.
- It is prepared from sodium carbonate (Na_2CO_3) by recrystallization through the Solvay process, which involves the reaction of sodium chloride with ammonia and carbon dioxide in water.
- It is used for removing permanent hardness of water, removing grease from clothes, and in the manufacture of glass, soap, borax, paper, etc.

Sodium Bicarbonate ($NaHCO_3$):

- Also known as **baking soda** (sodium hydrogen carbonate or cooking soda).
- It is prepared by the reaction of common salt (NaCl), carbon dioxide (CO_2), ammonia (NH_3), and water (H_2O).

$NaCl + CO_2 + NH_3 + H_2O \rightarrow NaHCO_3 + NH_4Cl$

- It is used in fire extinguishers, bakery products, and medicines.
- It is used for the permanent removal of water hardness.

Glauber's Salt ($Na_2SO_4 \cdot 10H_2O$):

- Used in the manufacture of water glass, paper, detergents, medicines, and sodium sulphide.

Sodium Peroxide (Na_2O_2):

- In the structure of sodium peroxide, each sodium atom is bonded to oxygen, and two oxygen atoms are bonded together, forming a peroxide linkage.
- It is a yellow-colored powder.
- Used in the preparation of hydrogen peroxide, bleaching of wool and silk, and purification of air in ships and submarines.

Borax ($Na_2B_4O_7 \cdot 10H_2O$):

- A white crystalline solid used in glass and candle industries, glazing of ceramics and paper, leather dyeing, and water purification.

Sodium Thiosulphate ($Na_2S_2O_3$):

- Used by photographers for fixing developed negatives and prints.
- Used medically in the treatment of cyanide poisoning.
- Acts as a reducing agent in reactions with chlorine and iodine.

Sodium Benzoate (NaC_6H_5COO):

- Primarily used as a preservative.
- Commonly added to sauces, salad dressings, juices, soft drinks, and other beverages.
- Its antimicrobial properties prevent the growth of bacteria, fungi, and yeast in food.
- Sodium is the element mainly responsible for high blood pressure in humans.
- Excess intake of sodium, commonly present in table salt, can directly contribute to increased blood pressure. Increased sodium levels in the blood can lead to higher water absorption.

Potassium Hydroxide (KOH)

- Common name: **Caustic potash;** a strong alkali.
- Used in soap manufacture, preparation of potassium chemicals, and neutralization of acids in laboratories.

Potassium Chloride (KCl)

- Common name: **Muriate of potash**
- Source: Hydrochloric acid + Potassium hydroxide
- Used in the treatment of hypokalemia (low potassium levels in blood), agriculture, and industry.

Calcium Oxide (CaO):

- Used in cement, glass, bleaching powder, sugar refining, and in heating ammonia and alcohol.

Calcium Hydroxide (Slaked Lime) – $Ca(OH)_2$:

- A molecule contains two hydrogen atoms.
- Used in mortar, whitewashing, bleaching powder preparation, and glass manufacturing.
- Its solution is called lime water, and its suspension is called **milk of lime.**
- The saturated solution used in chemical industries is known as **caustic lime.**

Calcium Carbonate ($CaCO_3$):

- Source: Carbonic acid + Calcium hydroxide
- Calcium hydroxide reacts with carbon dioxide to form calcium carbonate (marble), commonly known as limestone:
  $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$
- On heating, calcium carbonate decomposes into calcium oxide and carbon dioxide.
- Used in building construction as marble and in paper and cosmetic industries.

Bleaching Powder (Calcium Oxychloride) – $CaOCl_2$:

- Also called **bleaching powder.**
- Widely used for bleaching cotton and linen in the textile industry, bleaching wood pulp in paper manufacturing, and disinfecting drinking water.

Gypsum (Calcium Sulphate Dihydrate) – $CaSO_4 \cdot 2H_2O$:

- A natural mineral found in crystalline or massive form.
- Used in wallboards, cement, and manufacture of plaster of Paris.

Plaster of Paris (Calcium Sulphate Hemihydrate) – $CaSO_4 \cdot \frac{1}{2}H_2O$:

- Obtained by heating gypsum at about 120°C.
- Used in plastering bones, making statues, and in dentistry.

Potash Alum (Fitkari) – Potassium Aluminium Sulphate Dodecahydrate

- $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$
- A double sulphate composed of potassium, aluminium, and sulphate ions in a 1:1:2 ratio.
- A colorless crystalline solid, soluble in water with an astringent taste.
- Used in water purification, leather industry, cosmetics (deodorant), and baking powder.

Potassium Permanganate ($KMnO_4$):

- An important manganese compound, purple in color and soluble in water. Its aqueous solution appears red and is therefore called "red medicine."
- Used as an antiseptic in skin infections, dermatitis, and fungal infections (such as athlete's foot).
- Used for washing wounds and treating ulcers.

- Due to its strong oxidizing nature, it is used in redox titration and qualitative and quantitative analysis.
- Also used in fire-starting devices (survival kits).

Silver Bromide (AgBr):

- Used in photographic films, X-ray films, and black-and-white photography.

Copper Sulphate ($CuSO_4$):

- A light green or greyish-white powder; its hydrated form is blue in color and is called blue vitriol.
- Used in fisheries, as a disinfectant, in electroplating, and as a catalyst in chemical industries.

Magnesium Hydroxide [$Mg(OH)_2$]:

- A white substance, slightly soluble in water.
- Its suspension in water is called **milk of magnesia.**
- Alkaline in nature and used as an antacid, laxative, in neutralization of acidic wastewater, dandruff treatment, and chewable tablets.

Magnesium Sulphate ($MgSO_4$):

- A colorless crystalline solid found near hot springs as Epsom salt.
- Used as a catalyst in sulphuric acid manufacture, ceramic cement, medicines, leather, and dye industries.

Magnesium Alba ($2MgCO_3 \cdot Mg(OH)_2 \cdot 3H_2O$):

- Used as an antacid to relieve stomach acidity.
- Also used as an abrasive in toothpaste and in cosmetic products.

White Vitriol

- Chemical name: Zinc sulphate heptahydrate ($ZnSO_4 \cdot 7H_2O$)
- An inorganic compound and dietary supplement.
- Main uses: Treatment of zinc deficiency, Oral Rehydration Therapy (ORT), and as a micronutrient in agriculture.

Important Fact

- **White Vitriol** = Zinc sulphate ($ZnSO_4 \cdot 7H_2O$)
- **Blue Vitriol** = Copper sulphate ($CuSO_4 \cdot 5H_2O$)
- **Green Vitriol** = Iron (II) sulphate or ferrous sulphate ($FeSO_4 \cdot 7H_2O$)

Carbon Monoxide (CO):

- A colorless, odorless, and tasteless gas that is highly poisonous.
- Formed by incomplete combustion of carbon-containing fuels (wood, coal, petrol).
- Binds more strongly with hemoglobin than oxygen, reducing oxygen supply in the body.
- Used in the manufacture of chemicals such as methanol and acetic acid, in metallurgy, and in synthesis gas (syngas) production.

Carbon Dioxide (CO_2):

- A colorless and odorless gas naturally present in the atmosphere.
- Produced by complete combustion of carbon-containing substances, respiration of living organisms, fermentation, and industrial processes.
- When cooled and compressed beyond its critical temperature and pressure, it forms a supercritical fluid.
- Used in soft drinks, fire extinguishers, as a greenhouse gas, and as a shielding gas.

Dry Ice (Solid CO_2):

- The solid form of carbon dioxide that directly changes into gas at −78.5°C.
- It bypasses the liquid state and changes directly from solid to gas.
- Used in refrigeration, theatrical fog, food preservation, and fire extinguishing as it is heavier than air and non-flammable.

Heavy Water (D_2O):

- Chemically similar to ordinary water but contains deuterium (^2H) instead of normal hydrogen (^1H).
- Used as a neutron moderator in nuclear reactors (such as CANDU reactors), as a tracer in scientific research, and as an NMR solvent in spectroscopy.

Hydrogen Peroxide (H_2O_2):

- A pale blue liquid and a strong oxidizing agent.
- It is unstable and decomposes into water and oxygen over time.
- Used as a disinfectant, bleaching agent for hair, textiles and paper, antiseptic (perhydrol), milk and wine testing, restoration of old paintings, and in rocket and submarine fuel systems due to oxygen-releasing ability.

Synthesis Gas (Syngas):

- Mainly composed of carbon monoxide (CO) and hydrogen (H_2).
- It Called synthesis gas because it is used in the synthesis of various chemicals such as methanol, ammonia, and hydrocarbons.
- Uses include methanol production, liquid fuel production through the Fischer–Tropsch process, ammonia production (hydrogen source for Haber process), and energy generation (fuel for gas turbines and boilers).

Water (H_2O):

- A colorless, odorless, and tasteless liquid essential for all known forms of life.
- A pure sample of water always contains 88.89% oxygen and 11.1% hydrogen by mass.
- Composed of two hydrogen atoms and one oxygen atom joined by covalent bonds; the mass ratio of hydrogen to oxygen is 1:8. The relative molecular mass of water is 18 u.
- Water covers about 71% of Earth's surface and is essential for biological, chemical, and physical processes.
- Rainwater is considered the purest natural form of water. Distilled water is a poor conductor of electricity.
- In 1784, Henry Cavendish discovered the composition of water through experiments with hydrogen and oxygen.

Ammonia (NH_3):

- Chemical name: Nitrogen trihydride.
- Ammonia was first obtained by J. Priestley by heating ammonium chloride with lime and was called alkaline air. Later, Berthollet identified it in 1785. Ammonia is a compound of nitrogen and hydrogen.
- A concentrated aqueous solution of ammonia is called liquor ammonia.
- The foul smell around toilets and stables is mainly due to ammonia formed by decomposition of urine (urea).
- **Uses:** Used in the manufacture of nitrogenous fertilizers and nitric acid; liquid ammonia is used as a refrigerant.

Nitric Acid (HNO_3):

- Nitric acid is produced on a large scale by the Ostwald process, in which ammonia is oxidized with atmospheric oxygen in the presence of a catalyst. It can also be prepared by the Birkeland–Eyde process and retort process.
- It is a colorless liquid with a highly acidic aqueous solution.
- A strong oxidizing agent that reacts with most metals except noble metals such as gold and platinum.
- Also called aqua fortis because it reacts with many metals.
- **Uses:** Used in the manufacture of fertilizers such as ammonium nitrate, explosives like TNT and TNG, and nitrates used in pyrotechnics.

Acids and Their Uses

Natural Acid	Chemical Formula	Source	Uses
Citric Acid	$C_6H_8O_7$	Citrus fruits such as lemon and orange	Used as a preservative, flavour enhancer, and cleaning agent.
Acetic Acid	CH_3COOH	Vinegar	Used as a food preservative, for cleaning, and as an industrial solvent. Added to vinegar, pickled vegetables, and sauces to provide sour taste.
Lactic Acid	$C_3H_6O_3$	Sour curd, muscles	Used in food products, cosmetics, and medicines.

Tartaric Acid	$C_4H_6O_6$	Grapes, tamarind	Used in baking powder, as a food acidulant, and in medicines.
Malic Acid	$C_4H_6O_5$	Apple, pear	Used in food products, skincare products, and for flavouring.
Oxalic Acid	$C_2H_2O_4$	Spinach, beetroot, tomato	Used for cleaning metals and in the dyeing industry.
Ascorbic Acid (Vitamin C)	$C_6H_8O_6$	Citrus fruits, strawberry, kiwi	Used as an antioxidant, to boost immunity, and as a food preservative.
Formic Acid (Methanoic Acid)	HCOOH	Ant sting, scorpion sting	Used in leather processing, textile industry, and as an antiseptic.
Benzoic Acid	$C_7H_6O_2$	Cranberries, prunes, apple	Used as a food preservative, antifungal agent, and in cosmetics.
Butyric Acid	$C_4H_8O_2$	Ghee, dairy products	Used for flavouring, in animal feed, and in medicines.
Erucic Acid	$C_{22}H_{42}O_2$	Mustard and rapeseed oil	Used in the manufacture of industrial lubricants, biodiesel production, and in the cosmetic and plastic industries.
Lauric Acid	$C_{12}H_{24}O_2$	Coconut oil and palm kernel oil	Used in making soap, shampoo, and detergents. Also used as an antimicrobial agent in cosmetics and pharmaceuticals to protect against bacteria and viruses.
Carbonic Acid	H_2CO_3	Formed from carbon dioxide dissolved in water	Used to create fizz and bubbles in soft drinks (carbonated beverages). Used in buffer systems to maintain blood pH balance. Used in industrial processes for producing carbonates and bicarbonates.

Chemistry in daily Life

Important Organic Compound

Naphthalene Balls - $C_{10}H_8$

- Naphthalene balls are made from coal tar.
- Naphthalene is a white, solid substance with a strong odor and is commonly used as an insect repellent.
- It is obtained by distillation and fractionation of coal tar, and the extracted material is further purified by fractionation, bleaching, and crystallization.
- Naphthalene balls are used to repel moths and other insects.

Ethanol (Ethyl Alcohol) — C_2H_5OH

- Ethanol is a common alcohol present in alcoholic beverages and is also used as a fuel and in thermometers.
- It is produced mainly by two methods: fermentation of sugars, in which yeast converts sugar into ethanol, and petrochemical processes such as ethylene hydration.
- Ethanol is also used as a fuel additive in gasoline, known as bioethanol, which helps reduce emissions.
- Its melting point is 156 K and boiling point is 351 K. Complete combustion of ethanol produces carbon dioxide, water, heat, and light.

Methyl Alcohol / Methanol — CH_3OH

- Methanol is produced when carbon monoxide (CO) reacts with hydrogen gas (H_2) under high pressure (about 340 atm): $CO(g) + 2H_2(g) \rightarrow CH_3OH(l)$
- This reaction is part of an industrial process known as synthesis gas or syngas conversion.
- Methanol is used in windshield washer fluid, as an antifreeze agent in natural gas pipelines, as a fuel, in chemical manufacturing, as a solvent, and as an industrial raw material.

Ethylene Glycol — $C_2H_6O_2$

- Ethylene glycol is a colorless, odorless liquid with a sweet taste and is a dihydric alcohol containing two –OH groups. Its boiling point is 197.6°C and melting point is −12.9°C.
- It is used in antifreeze and coolants, as a raw material in polyester fiber production, and as a solvent in paints, coatings, and varnishes.

Glycerol (Glycerin) — $C_3H_8O_3$

- Glycerol is a hygroscopic substance that attracts moisture from the atmosphere and helps maintain skin hydration.
- It is a colorless, odorless, viscous liquid with a boiling point of 290°C and a melting point of 17.8°C.
- It is widely used in moisturizers, soaps, and skincare products because it helps keep the skin soft and hydrated.

Benzaldehyde

- Benzaldehyde is a colorless liquid with a sweet almond-like aroma.
- It is used as a flavoring agent in foods, beverages, chocolates, and bakery products, and also as a fragrance in perfumes and cosmetics.
- It occurs naturally in almonds, cherries, apricots, and cinnamon.

Formaldehyde — HCHO

- Formaldehyde is used in perfumes where it acts as a stabilizing agent, helping fragrances last longer.
- It is a toxic compound that may cause irritation of mucous membranes, allergies, and long-term exposure may lead to certain types of cancer.
- It is also used in consumer products such as pressed wood products, foam insulation, antiseptics, medicines, cosmetics, and as a disinfectant.

Acetaldehyde — CH_3CHO

- Acetaldehyde is a colorless gas with a pungent and suffocating odor and has a boiling point of 20.8°C.
- It is an important intermediate in the manufacture of acids, pyridine, and other chemical compounds.
- It is used in the production of polyvinyl acetate, disinfectants, medicines, perfumes, and dyes.

Vinegar

- Vinegar is a dilute aqueous solution generally containing 5%–10% acetic acid and is used for both food preservation and flavoring.
- It is produced by fermentation of ethanol.
- It is used in cooking (salad dressing, pickles, sauces), as a preservative, and has also been observed to help reduce blood sugar levels in some cases.

Ethyl Acetate — $CH_3COOC_2H_5$

- Ethyl acetate is a colorless, flammable liquid with a fruity odor.
- It is widely used as a solvent in paints, varnishes, nail polish removers, and perfumes.

Chloroform / Trichloromethane — $CHCl_3$

- Chloroform was discovered by Liebig in 1831. It oxidizes in the presence of light to form toxic phosgene; therefore, it is stored in completely filled colored bottles.
- It is a colorless, heavy, non-flammable liquid with a sweet smell and was previously used as an anesthetic.
- Chloroform is used in the production of Freon refrigerant R-22.

Chlorofluorocarbons (CFCs)

- Chlorofluorocarbons, also called Freons, are highly stable, inert, and easily liquefied gases used as aerosol propellants, refrigerants, and in air conditioning systems. However, they contribute to depletion of the ozone layer.

Bromoform

- Bromoform (tribromomethane) is a colorless liquid with a sweet, chloroform-like odor.
- It is used as a solvent in the pharmaceutical industry, pesticides, and plastic manufacturing.

Plastics

Polyethylene (PE):

- It is made from ethylene monomer and has the structure $[-CH_2–CH_2-]_n$.
- It is used for making plastic bags, containers, bottles, and various types of packaging materials.

Polystyrene (PS):

- It is made from styrene monomer and has the structure $[-CH_2–CH(C_6H_5)-]_n$.
- It is used in disposable cutlery, packaging materials, insulation, and toys.

PVC (Polyvinyl Chloride):

- It is made from vinyl chloride monomer and has the structure $[-CH_2–CH(Cl)-]_n$.
- It is used in pipes, flooring, medical equipment, and items such as credit cards.

Polypropylene (PP):

- It is made from propylene monomer and has the structure $[-CH_2–CH(CH_3)-]_n$.
- It is used in packaging, automobile parts, textiles, ropes, and containers.

Lucite (Polymethyl Methacrylate, PMMA):

- It is made from methyl methacrylate monomer and has the structure $[-CH_2–C(CH_3)=O-]_n$.
- It is used in transparent plastic products such as windows, lenses, and signboards.

Bakelite:

- It is made from phenol and formaldehyde monomers and has the structure $[-CH_2OH–Ph–CH_2O-]_n$.
- It is used in electrical insulators, automobile parts, and kitchenware.

Melamine:

- It is made from melamine monomer and has the structure $[NH_2–C_6H_3–NH-]_n$.
- It is used in laminates, kitchenware, adhesives, and fire-retardant products.

Teflon (PTFE):

- It is made from tetrafluoroethylene monomer and has the structure $(C_2F_4)_n$. It is used in non-stick cookware, lubricants, waterproof fabrics, and electrical insulation because it is heat-resistant and has low friction.

Rubber

Natural Rubber:

- It is made from isoprene monomer and has the structure $[-CH_2–C(CH_3)=CH-]_n$.
- It is used in tires, shoes, gaskets, hoses, adhesives, and balloons.

Neoprene:

- It is made from chloroprene monomer and has the structure $[-CH_2–C(Cl)=CH-]_n$.
- It is used in wetsuits, industrial gaskets, electrical insulation, and adhesives.

Buna-N (Nitrile Rubber):

- It is made from butadiene and acrylonitrile monomers with structures $[-CH_2–CH=CH–CH_2-]_n$ and $[-CH_2–CH=CH–CN-]_n$.
- It is used in fuel hoses, gaskets, seals, automobile parts, and oil-resistant products.

Thiokol (Polysulfide Rubber):

- It is made from sodium polysulfide and has the structure $[-CH_2–S–S–CH_2-]_n$.
- It is used in fuel tanks, waterproof coatings, seals, and adhesives.

Fibres

Wool:

- It is made of protein (keratin) consisting of long, coiled chains of amino acids.
- It is used for making sweaters, coats, carpets, and blankets.

Silk:

- It is made of protein (fibroin) containing smooth amino acid chains.
- It is used in luxury fabrics, scarves, and medical sutures.

Cotton:

- It is made of cellulose having a straight-chain structure.
- It is used for making shirts, jeans, dresses, bedsheets, and towels.

Jute:

- It is also made of cellulose with a straight-chain structure.
- It is used for making bags, ropes, mats, and biodegradable packaging.

Nylon:

- It is made from adipic acid and hexamethylenediamine and contains a polyamide chain.
- It is used in fabrics, ropes, industrial textiles, and parachutes.

Nylon-6:

- It is made from caprolactam and has the structure $(C_6H_{11}NO)_n$. It is used in textiles, ropes, industrial fibers, and engineering plastics.

Polyester:

- It is made from terephthalic acid and ethylene glycol and contains long ester chains.
- It is used for making clothes, curtains, and PET bottles.

Acrylic:

- It is made from acrylonitrile monomer in which –C=C– units are repeated.
- It is used for making sweaters, socks, blankets, and carpets.

Rayon:

- It is made from cellulose (wood pulp or cotton) and resembles natural fiber.
- It is used in clothing, bed linen, and medical bandages.

Orlon:

- It is made from a polymer of acrylonitrile having a polyacrylonitrile structure.
- It is used in sweaters, socks, blankets, carpets, and upholstery.

Explosives

Trinitroglycerin (Nitroglycerin) — $C_3H_5N_3O_9$:

- A highly sensitive and volatile liquid, also called nitroglycerin, and a nitrate ester of glycerin.
- It is used in the manufacture of dynamite, in heart medicines, and in detonators.

Trinitrotoluene (TNT) — $C_6H_2(NO_2)_3CH_3$:

- A yellow crystalline solid formed by nitration of toluene (methylbenzene) and widely used as an explosive.
- Its main use is in military explosives, bombs, and shells.

RDX (Research Department Explosive) — $C_3H_6N_6O_6$:

- A highly powerful explosive also known as cyclonite or hexogen, and it is a nitramine compound.
- It is used in military explosives, bombs, and as a blasting agent in mining.

Trinitrophenol (Picric Acid) — $C_6H_3(NH_2)(NO_2)_3O$:

- A yellow crystalline compound, highly explosive and a nitrophenol derivative.
- It is used in military explosives, shells, and as a chemical intermediate.

Dynamite:

- A mixture of trinitroglycerin and an absorbent material (such as diatomaceous earth).
- It is a solid explosive in which trinitroglycerin is absorbed in an inert material, making it safer and more stable.
- It is widely used in mining, construction, and demolition for controlled explosions.

Gunpowder (Black Powder):

- A mixture of potassium nitrate, sulfur, and charcoal, where charcoal and sulfur act as fuel and potassium nitrate acts as an oxidizer.
- It was the first chemical explosive in history and its invention is credited to Roger Bacon.
- It remained the primary explosive material until the late nineteenth century.

Fuels

Petrol:

- Source: Crude oil. It is a liquid fuel obtained from crude oil consisting mainly of alkanes and aromatics.
- Used as fuel in cars, motorcycles, small engines, and gasoline-powered vehicles.

Diesel:

- Source: Crude oil. A heavier fraction of crude oil containing long-chain hydrocarbons.
- Used in trucks, buses, ships, generators, and diesel vehicles.

Kerosene:

- Source: Crude oil. A lighter liquid fuel than diesel obtained from crude oil.
- Used for heating, and for cooking and lighting in rural areas.

LPG (Liquefied Petroleum Gas):

- Source: Propane and butane obtained from natural gas and crude oil.
- A mixture stored in liquid form under pressure.

- Used for cooking, heating, vehicles (autogas), and industry.

Note: Propane (C_3H_8) is used as a combustible gas. It burns with a bright flame and is used in camping stoves and gas lanterns.

CNG (Compressed Natural Gas):

- Source: Natural gas (methane). Methane gas is compressed in high-pressure cylinders.
- It is odorless, tasteless, and non-toxic, consisting mainly of methane along with nitrogen, carbon dioxide, propane, and ethane.
- The main component is methane (CH_4). Used in CNG vehicles, industries, and as an alternative transport fuel. CNG is compressed up to about 200–250 kg/cm².

Ethanol:

- Source: Plants (maize, sugarcane, cellulose).
- An alcohol obtained by fermentation of plant sugars.
- Used as biofuel for vehicles, as a solvent, and in alcoholic beverages.

Biogas:

- Source: Organic waste (cow dung, food waste, sewage).
- A mixture of methane and carbon dioxide formed by anaerobic decomposition of organic matter.
- Used for electricity generation, cooking, heating, and as a renewable energy source.

Biodiesel:

- Source: Vegetable oils or animal fats. A renewable fuel produced by converting them into fatty acid methyl esters (FAME).
- Used as a substitute for diesel in vehicles, generators, and industrial machinery.

Hydrogen:

- Source: Water (by electrolysis) or natural gas.
- A clean fuel that produces no carbon emissions when burned or used in fuel cells.
- Used in hydrogen-powered vehicles, fuel cells, and industrial processes such as ammonia production.

Methane (Marsh Gas) — CH_4

- Methane is the main component of biogas and compressed natural gas (CNG).
- It is a greenhouse gas and the primary component of natural gas.
- Methane is a colorless, odorless, and highly flammable gas with a boiling point much lower than 111 K.
- Biogas generally contains about 75% methane (CH_4) and about 25% carbon dioxide (CO_2).
- Methane is commonly found in marshy areas and coal mines.

Soap

- Soap consists of sodium or potassium salts of long-chain fatty acids (RCOONa).
- Soaps are used to increase the cleaning capacity of water.

Saponification

- Saponification is the process in which fats or oils are converted into glycerol and soap by hydrolysis with a strong alkali (NaOH or KOH).

Fat/Oil (Triglyceride) + NaOH (alkali) → Glycerol + Soap (sodium salt of fatty acid)

Detergents

- Detergents are a special type of organic compounds that possess all the properties of soaps but are not soaps; therefore, they are also called soapless soaps.
- Detergents are sodium salts of long-chain monoalkyl sulfates or sodium salts of long-chain alkyl benzene sulfonic acids.
- Sodium carbonate (Na_2CO_3), also called soda ash, is a sodium product mainly used in the manufacture of detergents and soaps.

Glass

- Glass is a hard but brittle solid material made from a mixture of silica (SiO_2) and silicates. It is also called a "supercooled liquid" because it does not undergo crystallization.

Types of Glass, Their Properties, and Uses

1. **Soda Glass (Soft Glass):** Made from sodium carbonate, calcium carbonate, and silica; inexpensive and soft. Used in window panes, bottles, tube lights, bulbs, and glass utensils.

2. **Potash Glass (Hard Glass):** Made from potassium carbonate and silica; harder than soda glass. Used for making beakers, flasks, and high-temperature resistant equipment.
3. **Photochromic Glass:** Becomes dark in bright light and filters sunlight, and returns to a colorless state in darkness due to the presence of AgBr molecules. Used in sunglasses.
4. **Pyrex Glass or Borosilicate Glass:** Contains boric oxide and silica; highly resistant to heat and chemical reactions. Used for making laboratory equipment.
5. **Lead Glass:** Contains sodium, potassium, and lead silicates; shiny with a high refractive index. Used for high-quality utensils, gift items, and artificial gems.
6. **Crown Glass:** Contains compounds of potassium, sodium, and silica; has a low refractive index. Used in making lenses.
7. **Jena Glass (Acid-resistant type):** Contains boric oxide and aluminium oxide; strong and resistant to acids and alkalis. Used for making bottles and containers for storing acidic and alkaline chemicals.
8. **Sapphire Glass:** Contains cerium oxide (CeO_2); absorbs ultraviolet (UV) rays. Used in spectacle lenses and protective glasses for children's eyes.
9. **Lead Crystal Glass:** Contains a high amount of lead oxide; bright and attractive. Used for decorative glassware and showpieces.
10. **Quartz Glass or Silica Glass:** Made from nearly pure silica. Used for making lenses for ultraviolet rays and laboratory equipment.

Types of Artificial Sweeteners

Sweetener	Chemical Structure	Sweetness Compared to Sucrose	Uses	Properties
Aspartame	Phenylalanine + Aspartic acid + Methanol	~200 times sweeter	Diet soda, sugar-free chewing gum, desserts	Heat-sensitive; breaks down at high temperatures. Contains phenylalanine, which may be harmful for PKU patients.
Saccharin	Ortho-sulfobenzamide, benzene sulfonamide derivative	~300–500 times	Beverages, tabletop sweeteners, canned products	Heat-stable; widely used in low-calorie products.
Sucralose	Chlorinated sugar (derived from sucrose)	~600 times	Baked products, beverages, candy	Heat-stable, calorie-free, remains stable at high temperatures.
Stevia	Steviol glycosides (from the stevia plant)	~50–300 times	Beverages, sugar-free foods, diet products	Natural, calorie-free, plant-derived.
Cyclamate	Sodium salt of cyclohexyl sulfuric acid	~30–50 times	Tabletop sweeteners, beverages, sugar-free products	Heat-stable, calorie-free; restricted in some countries at high consumption levels.
Acesulfame K	Potassium salt	~200 times	Sugar-free chewing gum, beverages, tabletop sweeteners	Heat-stable, calorie-free; often blended with other sweeteners to improve taste.
Xylitol	Sugar alcohol ($C_5H_{12}O_5$)	Similar to sucrose	Sugar-free gum, candy, oral care products	Lower calories than sucrose; excessive intake may cause digestive problems.

Alitame	$C_{14}H_{25}N_3O_4S$	~2000 times sweeter than sucrose	Soft drinks, baked goods, desserts	More potent than aspartame but less commonly used due to regulatory limitations.
Erythritol	Sugar alcohol ($C_4H_{10}O_4$)	~60–80% as sweet as sucrose	Low-calorie foods, sugar-free desserts, beverages	Calorie-free, easily digestible, causes less gas or bloating compared to other sugar alcohols.

Types of Drugs

Type	Definition	Uses	Examples
Antipyretics	Medicines that reduce fever by lowering body temperature. They act on the hypothalamus of the brain.	Reducing fever in flu, cold, and infections; relief from mild pain such as headache and toothache.	Paracetamol, Aspirin, Ibuprofen
Analgesics	Medicines that relieve pain by blocking pain signals or altering the perception of pain in the brain.	Mild to severe pain such as headache, muscle pain, post-operative pain, and cancer pain.	Aspirin, Paracetamol, Codeine, Morphine, Opioids
Antibiotics	Medicines that inhibit the growth of or destroy bacteria.	Bacterial infections such as pneumonia and urinary tract infections; prevention of infection after surgery.	Penicillin, Amoxicillin, Tetracycline, Ciprofloxacin
Antiseptics	Chemicals that prevent the growth of microorganisms on living tissues.	Cleaning wounds, cuts, surgical sites; mouthwash use.	Iodine, Hydrogen Peroxide, Chlorhexidine
Disinfectants	Chemicals that destroy microorganisms on non-living surfaces.	Cleaning hospital, kitchen, and bathroom surfaces; sterilizing equipment.	Bleach (Sodium Hypochlorite), Formaldehyde, Alcohol-based disinfectants
Sulfa Drugs	Antibiotic drugs containing the sulfonamide group.	Urinary infections and respiratory infections.	Sulfamethoxazole, Sulfadiazine
Anesthesia	Used to prevent pain during surgery or medical procedures; may be local, regional, or general.	Temporary loss of sensation or consciousness during operations.	Lidocaine (local), Propofol (general), Isoflurane (inhaled)
Antacids	Medicines that neutralize stomach acid.	Acidity, heartburn, and gastric irritation.	Magnesium Hydroxide, Calcium Carbonate, Sodium Bicarbonate
Histamine	A compound involved in immune response; released during allergies causing inflammation and itching.	Allergy treatment such as hay fever and hives.	Diphenhydramine, Loratadine
Equanil	A tranquilizer used to reduce stress and anxiety.	Anxiety, muscle tension, insomnia.	Meprobamate (brand name: Equanil)

Alloys and Their Uses

Alloy	Constituent Elements	Uses
Brass	Copper and zinc	Screw wires, cooking utensils, machine parts, ornaments, musical instruments, etc.
Bronze	Copper and tin	Coins, cooking utensils, ornaments, medals, etc.

German Silver	Copper, zinc and nickel	Silverware, electroplating, etc.
Sterling Silver	Copper and silver	Jewellery, silverware, etc.
Steel	Iron and carbon	Construction of railway lines, ships, bridges, machines, etc.
Stainless Steel	Iron, chromium, nickel and carbon	Cutlery, cooking utensils, surgical instruments, etc.
Duralumin	Aluminium, copper, magnesium and manganese	Making aircraft parts, space satellites
Magnalium	Aluminium and magnesium	Aeroplane parts
Alnico	Aluminium, nickel, cobalt and iron	Making magnets
Solder	Lead and tin	Soldering joints, etc.
Nichrome	Nickel, iron, chromium and manganese	Electrical heating elements
Amalgam	Mercury, silver, tin and zinc	Teeth filling

Human Body System

Cell: The Basic Unit of Life

- All living organisms are composed of one or more **basic units called cells.**
- The cell is regarded as the structural and functional unit of life because all vital activities necessary for survival take place within it.
- In **1665, Robert Hooke first observed** and described cells while examining a thin slice of cork using a primitive microscope.
- Cells carry out all essential life processes, either independently or as part of a larger organism.
- Organisms made up of a single cell are called **unicellular organisms**, for example, *Nostoc*, yeast, *Amoeba*, and *Paramecium*.
- Organisms composed of many cells are known as **multicellular organisms**, such as algae, fungi, plants, and animals.
- Some biological entities, such as viruses, do not possess cellular organization and are therefore described as **acellular**.
- Cells vary greatly in shape and size depending on their function and the type of organism. Some cells have a fixed shape, as seen in most plant and animal cells. Others may be spherical, such as the ovum; spindle-shaped, like muscle cells; or elongated and branched, such as nerve cells. Many unicellular organisms can change their shape.
  - ✓ For example, *Amoeba* alters its shape by forming pseudopodia, which help in movement and capturing food. Similarly, white blood cells (WBCs) in humans can also change their shape.
- Despite their diversity and complexity, all cells are broadly classified into two main types: **prokaryotic** and **eukaryotic** cells.
  - ✓ Prokaryotic cells lack a true nucleus and membrane-bound organelles; examples include bacteria, blue-green algae (cyanobacteria), and mycoplasma.
  - ✓ In contrast, eukaryotic cells possess a well-defined nucleus enclosed by a nuclear membrane and contain membrane-bound organelles; examples include algae, fungi, plants, and animals.

Components of a Cell

- A cell consists of several important components, each performing specific functions necessary for the survival and proper functioning of the organism.

1. **Plasma Membrane:** The plasma membrane is mainly composed of lipids and proteins, which provide flexibility and structural support. It is a selectively permeable membrane that allows only certain substances to pass through it. The plasma membrane separates the cell from the surrounding environment and also helps maintain the internal conditions of the cell.