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PREFACE

THE ANALYSIS OF INORGANIC ELEMENTS IS A CRITICAL COMPONENT IN VARIOUS FIELDS, INCLUDING ENVIRONMENTAL SCIENCE, MATERIALS SCIENCE, AND INDUSTRIAL QUALITY CONTROL. TO ENSURE THAT GRADUATES ARE WELL-PREPARED FOR PROFESSIONAL ROLES, IT IS ESSENTIAL TO ALIGN THE EDUCATIONAL CURRICULUM WITH ESTABLISHED NATIONAL STANDARDS. THIS BOOK PRESENTS A COMPREHENSIVE APPROACH TO INTEGRATING INDIAN STANDARDS FOR INORGANIC ELEMENT ANALYSIS WITH THE TECHNIQUES TAUGHT IN COLLEGES, THEREBY BRIDGING THE GAP BETWEEN ACADEMIC KNOWLEDGE AND INDUSTRY REQUIREMENTS.

Indian standards set by the Bureau of Indian Standards (BIS), provide detailed guidelines and protocols for the analysis of inorganic elements. Techniques like Atomic Absorption Spectroscopy (AAS), Inductively Coupled Plasma Mass Spectrometry (ICP-MS), X-Ray Fluorescence (XRF), and Gravimetric Analysis are routinely taught in college laboratories. However, there has been a need to systematically incorporate these standards into the educational framework to enhance the practical skills and industry-readiness of students.

The primary objective of this book is to create a cohesive educational model that integrates Indian standards into the teaching of inorganic analysis techniques.

This aims to:

1. Ensure that students are proficient in both theoretical knowledge and practical application of analytical techniques.
2. Familiarize students with the relevant BIS standards and their importance in ensuring accuracy, reliability, and compliance in analytical work.
3. Bridge the gap between academic education and industry practices, enhancing the employability of graduates.

The primary objective of this book is to create a cohesive educational model that integrates Indian standards into the teaching of inorganic analysis techniques.

Through detailed explanations, practical examples, and case studies, we hope to equip readers with the knowledge and skills necessary to excel in the field of inorganic chemistry.

CHAPTER I
INTRODUCTION

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INTRODUCTION

Inorganic chemistry, a fundamental branch of chemistry, deals with synthesis, properties and behaviour of inorganic and organometallic compounds. This field covers chemical compounds that are not carbon-based, which are the subjects of organic chemistry. The distinction between the two disciplines is, however not absolute, as there is remarkable overlap in the subdiscipline of organometallic chemistry. Nevertheless, inorganic chemistry has applications in every aspect of the chemical industry, including catalysis, materials science, pigments, surfactants, coatings, medications, fuels, and agriculture.

Metals serve an essential role in many aspects of human civilization and have defined ages of human history. It was as long back as the Bronze Age, between the time period of about 3300 BC to 1200 BC that our ancestors first started using metal and learned to mix various elements with copper to make a strong alloy, called bronze. This age yielded significant advancement in the crafting of sharper knives and stronger weapons out of metal instead of rock, wood and bone. Around 1200 BC the human race found an even harder metal and discovered a much stronger alloy called steel. This period is known as the Iron Age.

More recently, periods of time known as Gold Rushes have caused huge changes in population distributions and wealth in some countries. Metal has obvious importance in our modern way of life. Today, metals mark their presence in almost all sectors of human subsistence, with iron and steel being used for making buildings, machines, automobiles, cooking pots, tools, weapons, electronics, surgical instruments and symbolic structures like the Eiffel Tower and the Statue of Liberty, etc. Gold and silver are used for jewellery.

2.1. Scope of Inorganic Chemistry

The diverse field of Inorganic Chemistry encompasses a wide range of substances, including metals, minerals, salts, and organometallic compounds, which do not fall under the category of organic compounds primarily made of carbon and hydrogen. Inorganic chemistry is crucial for understanding the materials and processes that form the backbone of industries, environmental systems, and biological functions.

Inorganic chemistry is characterized by its vast scope, covering all elements in the periodic table and their compounds, except for the numerous organic compounds. It involves the study of:

a. **Elements and Compounds:** From simple salts to complex coordination compounds.

b. **Materials Science:** Development and characterization of metals, ceramics, and semiconductors.

c. **Bioinorganic Chemistry:** Role of metal ions in biological systems.

d. **Environmental Chemistry:** Understanding and mitigating the effects of inorganic pollutants.

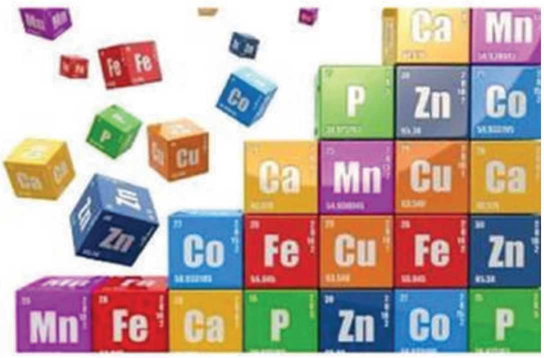
e. **Industrial Applications:** Catalysts, pigments, coatings, and more.

Inorganic chemistry is used in various fields ranging from mining to microchips. This is based on understanding:

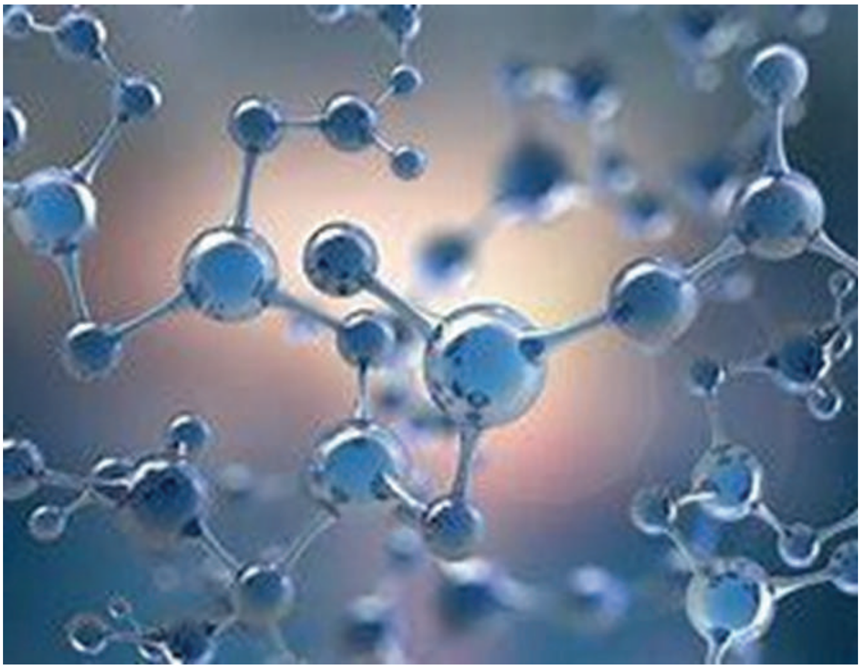
- The behaviour and analogues for inorganic elements, and
- How these materials can be modified, separated, and used.

The role of Inorganic Chemistry is not limited to but finds applications in:

- Developing methods to recover metals from waste streams
- Analysis of mined ores
- Performing research on the use of inorganic chemicals in various fields.



2.2. Importance of Analytical Techniques in Inorganic Chemistry



Analytical techniques in inorganic chemistry are essential for characterizing materials, understanding their properties, and ensuring quality control in various applications. These techniques allow chemists to identify and quantify the elements and compounds present in a sample, understand their structure, and study their behavior under different conditions. The accuracy and reliability of these analyses are critical for research, industrial applications, and environmental monitoring

2.3. Methods to Identify and Quantify Inorganic Elements

There are four methods to identify and quantify inorganic elements. These are:

1. **Spectroscopy:** Spectrometry involves measuring the interactions between light and matter, as well as the intensity and wavelength of radiation.
2. **Chromatography:** Chromatography serves as a method employed to separate the constituents within a mixture.
3. **Titration bases techniques:** Titration involves utilizing a solution with a known concentration to ascertain the concentration of an unknown solution.
4. **Gravimetric Techniques:** Gravimetric analysis is a quantitative analytical method based on the measurement of mass, which involves the separation and determination of the amount of a substance by weighing.

2.4. Integration with Indian Standards

Aligning these analytical techniques with Indian standards, is crucial for ensuring the accuracy, reliability, and comparability of analytical results. These standards provide guidelines and protocols that help maintain consistency across different laboratories and industries, facilitating quality control, regulatory compliance, and international trade.

Linking these Indian standards with the educational curriculum of engineering colleges is essential for preparing students to meet professional demands. By learning and applying these standards, students gain practical skills that enhance their employability and competence in real-world scenarios.

2.5 Key Analytical Techniques

A Spectroscopy

- **Principle:** Measures the concentration of gas-phase atoms by absorbing optical radiation.
- **Applications:** Used extensively for analyzing metal concentrations in water, soil, and biological samples.

I. **Atomic Emission Spectroscopy : Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES**

- **Principle:** Ionizes the sample with inductively coupled plasma and then uses mass spectrometry to detect the ions.
- **Applications:** Highly sensitive technique for detecting trace elements and isotopes.

II. **Atomic Absorption Spectroscopy : UV Visible Spectroscopy**

- **Principle:** Measures the absorption of ultraviolet or visible light by a compound, which provides information about its electronic structure.
- **Applications:** Used to study transition metal complexes, concentration of solutions, and reaction kinetics.

B Chromatography

- **Principle:** Separation of molecules in mixture applied onto the surface or into the solid (stationary phase) while moving with mobile phase.
- **Applications:** Used in the detection and quantification of biomolecules including proteins, nucleic acids, enzymes, vitamins, etc..

C Titration

- **Principle:** Determination of volume or concentration of an unknown solution (analyte) with the help of a solution with known volume and/or concentration (titrant).
- **Applications:** Used for the detection and quantification of metals and other impurities in various samples including wastewater, food products, alcohols, jewellery etc.

D Gravimetric Analysis

- **Principle:** Measures the mass of an analyte or its derivative to determine its concentration.
- **Applications:** Simple and precise method for quantifying compounds in a sample, particularly useful for substances that can be easily precipitated and weighed.

CHAPTER III

ANALYTICAL TECHNIQUES AND THEIR APPLICATION IN INDIAN STANDARDS

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ANALYTICAL TECHNIQUES AND THEIR APPLICATION IN INDIAN STANDARDS

3.1 Spectroscopy : An Overview

Spectroscopy is a branch of science that deals with the study of the interaction between matter and electromagnetic radiation. It encompasses various techniques that involve the absorption, emission, or scattering of electromagnetic radiation by atoms or molecules. It is used for identification and quantification of different Analytes like Silver, Arsenic, Antimony, Barium, Copper, Aluminium, Lead etc in different sample matrices like Packaged Drinking Water / Packaged Natural Mineral Water, Common Salt, Sodium Hypochlorite etc.

- **Historical Perspective:**

The study of spectrometry traces back to Isaac Newton's discovery of the visible light spectrum. Over time, advancements led to the identification of spectral lines and their significance in understanding chemical composition and physical properties.

- **Spectrometry and its relation with Spectroscopy:**

Spectrometry involves measuring the interactions between light and matter as well as the intensity and wavelength of radiation. Mass spectrometry, a prominent example, measures the mass-to-charge ratio of particles within a sample to identify its composition. Spectrometry encompasses practical methods for analyzing spectra and generating quantitative measurements. While spectroscopy focuses on the theoretical study of energy-matter interactions, spectrometry involves practical measurements to quantify spectral characteristics. Spectroscopy lays the groundwork, while spectrometry generates tangible results for analysis.

- **Spectrometers: Absorption V/s Emission instruments**

In analytical spectroscopy, instruments fall into two main categories: those based on atomic absorption and those based on atomic emission. An example of the former is the Atomic Absorption Spectrometer, while an example of the latter is the Inductively Coupled Plasma (ICP) Spectrometer.

Both types of instruments operate on principles rooted in quantum mechanics, where electrons undergo specific energy transitions. When an electron moves from a lower energy state to a higher one, the atom absorbs energy; conversely, moving to a lower energy state results in the release of energy.

This energy transition manifests as light, with an ICP Spectrometer measuring the emitted light's wavelength, while an Atomic Absorption Spectrometer measures the absorbed light's wavelength during these transitions.

The unique wavelengths of absorbed (in atomic absorption spectrum) or emitted (in atomic emission spectrum) light for different atoms serve as a fingerprint for each element, allowing spectrometers to identify them (Figure 1). Typically, electrons shift to higher energy states when heated and return to lower states when cooled. Both instrument types usually employ rapid heating methods, such as air-acetylene flames or plasma.

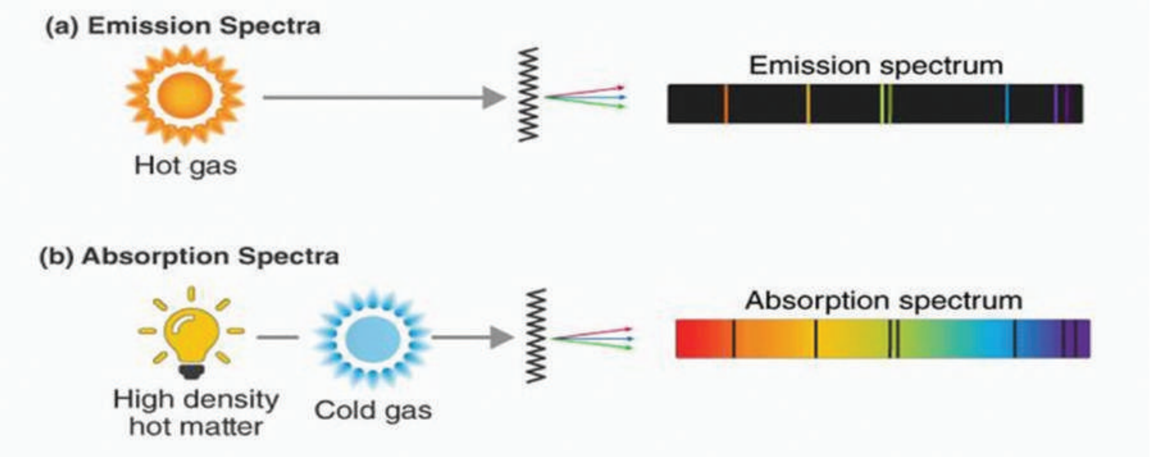
Instruments that use atomic emissions include:

- ICP Spectrometers (ICP AES)
- ICP Spectrometer – Mass Spectrometer (ICP-MS)
- Spark Spectrometers (Spark OES)
- Flame Emission Spectrometers

Instruments that use atomic absorption include:

- Spectroscopic flame systems
- Electrothermal graphite furnaces
- Hydride atomization systems

At temperatures exceeding 1200°C, electrons can transition to higher energy states but lack the internal energy for spontaneous transition. In the AtomicAbsorption Spectrometer, an external energy source provides the required wavelength energy for electron absorption. Conversely, in the ICP Spectrometer, the plasma itself furnishes sufficient internal energy for unaided electron transition to higher states. In the cooler exhaust zone, the ICP Spectrometer then measures the released energy wavelengths associated uniquely with each element.



3.1.1 Atomic Emission Techniues

Atomic emission spectroscopy or AES is a procedure of analysing chemicals that employs the intensity of light from a plasma, flame, arc or spark at a definite wavelength to calculate the quantitative presence of an element in a particular sample. The atomic spectral line wavelength identifies the element and the intensity of light is proportional to the atom count of the element.

Principle

The theory or working principle of Atomic Emission Spectroscopy involves the examination of the wavelengths of photons discharged by atoms and molecules as they transit from a high energy state to a low energy state. A characteristic set of wavelengths is emitted by each element or substance which depends on its electronic structure. A study of these wavelengths can reveal the elemental structure of the sample.When a ground state atom is collided with light of appropriate wavelength, the atom absorbs the light and enters an excited phase. This process is referred to as atomic absorption. The aim of atomic absorption is to measure the quantity of light at resonant wavelength that is absorbed when it passes through a cluster of atoms. The increase in the amount of absorbed light is proportional to the increase in the number of atoms on the light stream. The quantity of analyte substance present can be calculated by measuring the quantity of absorbed light. The quantitative determination of varied individual elements in presence of other substances is aided by the employment of special light sources as well as the appropriate selection of light wavelength. The atom cloud needed for measuring atomic absorption is produced by exposing the sample to enough thermal energy. This dissociates the structures of chemical compounds and liberates free atoms (Figure 2). This purpose is served by presenting the sample solution into the flame coordinated with the light beam. The majority of atoms will stay in the ground state form when exposed to appropriate flame conditions. These atoms can absorb light emitted from the source lamp at specific analytical wavelength. Atomic Absorption Spectroscopy offers great speed and ease while making comprehensive and accurate calculations and hence it is among the most widely used methods for determining metal samples.

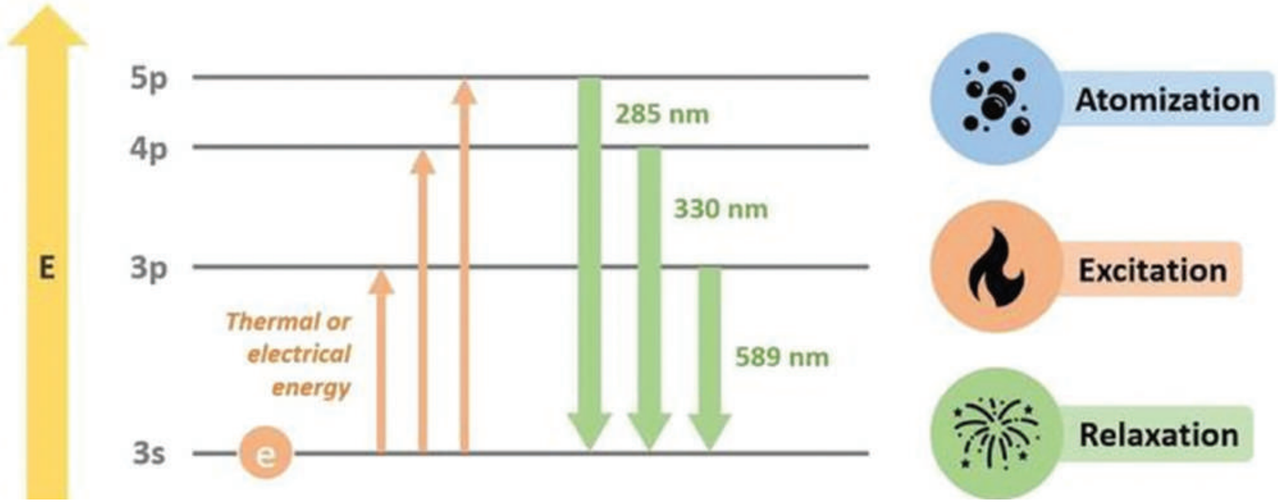


Figure 2: Change in Energy Levels of Electrons during Atomic Spectroscopy

Applications

The principal application of atomic emission spectroscopy is to determine the proportional quantity of a particular element in a given sample. The various methods of atomic emission spectroscopy are utilized to examine different substances such as foods and drinks, motor oil and soil samples. Atomic Emission Spectroscopy is predominantly utilized in space research labs by NASA and ESA. It is also used for aiding various military operations.

Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES)

Inductively coupled plasma atomic emission spectroscopy (ICP-AES) employs the use of inductively coupled plasma for producing excited ions and atoms that radiate electromagnetically charged particles at wavelengths characteristic to a definite element.

Principle

Inductively coupled plasma atomic emission spectroscopy (ICP-OES or ICP- AES) is an analytical spectroscopic technique that relies on optical emission for analysis and gives information about how much of certain elements are in a sample. It is widely used to analyze liquid samples as well as substances that are easily dissolved or digested into liquid form.

Applications

Inductively coupled plasma atomic emission spectroscopy is used to determine the presence of arsenic in food, metals in wine and to study trace elements that are bound to proteins.

ICP-AES is frequently used for analysing trace elements present in the soil. Forensic experts use this method to study soil samples found at the crime scenes and ascertain their origin. The metal composition of two types of soil samples can be compared to determine the origin of the soil samples taken from crime scene.

ICP-AES is also used for analysing motor oils. The results from such studies help in determining the life of the oil, as well as assist in quality control and help in functional efficiency of automobile engines

Application in Indian Standards

Various Indian Standards have been developed that use ICP-AES and ICP-MS etc. for the determination of trace elements in soil samples, alloys, waste water treatment process, oils and fats samples, leather products etc. A comprehensive list of Indian Standards using various Atomic Emission Techniques are enumerated in ***Annexure 1.*** *Further, IS 3025 (Part 2) :2004 has been discussed below for reference.*

Atomic Emission Spectroscopy Analysis Procedure

IS 3025 (Part 2) :2004
ISO 11885:1996
Indian Standard
METHODS OF SAMPLING AND TEST (PHYSICAL
AND CHEMICAL) FOR WATER AND WASTE WATER

PART 2 DETERMINATION OF 33 ELEMENTS BY INDUCTIVELY COUPLED PLASMA ATOMIC EMISSION SPECTROSCOPY

Principle

The basis of the method is the measurement of atomic emission by an optical spectroscopic technique. Samples are nebulized and the aerosol that is produced is transported to the plasma torch where excitation occurs. Characteristic atomic-line emission spectra are produced by a radio-frequency inductively coupled plasma (ICP). The spectra are dispersed by a grating spectrometer and the intensities of the lines are monitored by detectors. The signals from the detectors are processed and controlled by a computer system. A background correction technique is used to compensate for variable background contributions to the determination of trace elements.

Reagent

- General requirements: Standard stock solutions may be purchased or prepared from ultra-high-purity grade chemicals. The content of the determinants in the water and reagents shall be negligibly low, compared with the concentrations to be determined.
- Nitric acid, ñ(HNO_3) = 1.40 g/ml
- Dihydrogen dioxide (hydrogen peroxide), H_2O_2, volume fraction 30%.: On the determination of phosphorus, attention should be paid to a possible stabilization of hydrogen peroxide with phosphoric acid, as this will affect the phosphorous determination.
- Sulfuric acid, p(H_2S04) = 1.84 g/ml.
- Hydrochloric acid, of HCl) = 0.2 mol/1.
- Ammonium sulfate, $(NH_4)_2S0_4$.
- Element stock solutions
- Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Se, Si, Sn, Sr, Ti, V, W and Zn at mass concentrations of 1000 mg/1each: ICP-AES element standard reference solutions with respective specifications which can be used as stock solutions are commercially available. They have been prepared according to particulars of the manufacturer. Normally, these stock solutions contain hydrochloric acid or nitric acid and have a shelf life of several months. Formulations for the preparation of element stock solutions are identified below.

- Intermediate mixed standard solutions: Prepare these as mixed element standards in 594 nitric acid or 5 % hydrochloric acid (volume fraction). To ensure chemical compatibility use the combinations given in 5.8.1 to 5.8.6. On composing multielement reference solutions, the chemical compatibility and the possible hydrolysis of the initial compounds, as well as spectral interferences, shall be taken into account. In order to avoid interferences, the digestion reagents (e.g. nitric acid, sulfuric acid, aqua regia) shall be added to the reference solutions

Instrumental method and analytical procedure

Instrumental method

- **General**:
    - Set up the instrument with the proper operating parameters established from the manufacturer's instruction manual. Allow the instrument to become thermally stable before beginning.
    - Initiate the appropriate operating configuration of the computer.
    - Before beginning the sample run, reanalyse the highest-concentration mixed reference standard as if it were a sample. Ensure that the concentration values do not deviate from the actual values by more than *5% (or the established control limits, whichever is lower). If they do, follow the recommendations of the instrument manufacturer to correct for this condition.
    - Begin the sample run by flushing the system with the reagent blank (5.8.7) solution and flush again between each sample. Analyse the instrument check standard (8.1.2) and the calibration blank every 10 samples.
- **Instrument performance check procedure:**
    - Analyse an appropriate instrument check standard containing the elements of interest with each batch of 10 samples. This check standard is used to determine instrument drift. If agreement is not within * 5 % of the expected values or within the established control limits, whichever is lower, the analysis is out of control. Terminate the analysis, correct the problem, and recalibrate the instrument.
    - Analyse the reference standard with each batch of 10 samples. The result shall be within the established control limits of two standard deviations of the mean value. If not, repeat the analysis two more times and average the three results. If the average is not within the control limit, terminate the analysis, correct the problem and recalibrate the instrument.
    - To verify interelement and background correction factors, analyse the instrument check standard at the beginning, end and at periodic intervals throughout the sample run. Results should fall within the established control limits of 2,0 times the standard deviation of the mean value. If not, terminate the analysis, correct the problem and recalibrate the instrument.

- **Independent Calibration Check**

  - An independent calibration standard obtained from an outside source shall first be used for the initial verification of the calibration standards. A fresh dilution of this sample shall be analysed every week thereafter to monitor their stability. If the results are not within * 5 YO of the true value listed for the control sample, prepare a new calibration standard and recalibrate the instrument. If this does not correct the problem, prepare a new stock standard and a new calibration standard and repeat the calibration.

  - Prepare calibration check standards for all elements from stock solutions reserved for this purpose consisting of the same matrix as the unknown samples and carried through the entire analytical process.

  - Analyse one calibration standard and one blank solution with each batch of 25 samples and take them through the entire analytical processes (including dilution, filtering and digestion, etc.).

- **Standard Addition Method of Analysis**

  - The standard addition technique involves preparing new standards in the sample matrix by adding known amounts of standard to one or more aliquots of the processed sample solution. This technique compensates for a sample constituent that enhances or depresses the analyte signal, thus producing a different slope from that of the calibration standards. It will not correct for additive interference. The simplest version of this technique is the single-addition method.

  - Take two identical aliquots of the sample solution, each of volume V_s To the first (Iabelled A) add a small volume V_s of a standard analyte solution of concentration $\tilde{n}_S$ of the solvent. Measure the analytical signals of A and B and correct for non analyte signals. Calculate the unknown sample concentration $\tilde{n}_X$ as follows

$$P_x = \frac{S_a\text{-}V_s\text{-}P_s}{(S_A\text{-}S) - V_x}$$

where

S_A, S_B are the analytical signals (corrected for the blank) of solutions A and B, respectively;

V_S is the added volume of standard analyte, in milliliters;

V_X is the volume of identical aliquots of sample solution, in millilitres;

$\tilde{n}_S$ is the mass concentration of standard analyte solution, in milligrams per Iitre.

Note: For the results from this technique to be valid, all of the following requirements shall apply:

— the analytical response shall be linear

— the chemical form of the analyte added shall respond the same as the analyte in the sample;

— the interference effect shall be constant over the working range of concern;

— the signal shall be corrected for any additive interference.

Analytical Procedure

- **Determination of Dissolved Elements**

  Analyse the filtered, preserved sample as-received in accordance with 8.1.1. The acid matrix and concentration of the samples and calibration standards shall be the same. If a precipitate has formed upon acidification of the sample or during transit or storage, it shall be redissolved before analysis by adding additional acid and/or by heating on a hot plate.

- **Determination of particulate elements**

  Transfer the membrane filter containing the insoluble material to a glass beaker and add 4 ml of nitric acid (5.2). Cover the beaker with a watch glass and heat gently. The warm acid will soon dissolve the membrane. Increase the temperature of the hot plate and digest the material. When the acid has nearly evaporated, cool the beaker and watch glass and add another 3 ml of nitric acid. Cover and continue heating until the digestion is complete, generally indicated by a Iight-coloured digestate. Evaporate to near dryness (2 ml), cool, add 10 ml of hydrochloric acid (0,2 mol/1) and 15 ml of deionized, distilled water per 100 ml dilution and warm the beaker gently for 15 min to dissolve any precipitated or residue material. Allow to cool, wash down the watch glass and beaker wails with deionized or distilled water and filter the sample to remove insoluble material which can block the nebulizer. Adjust the volume based on the expected concentrations of elements present. This volume will vary depending on the elements to be determined. Analyse the sample as per the method described in the General Section of Instrumental Method. Concentrations so determined shall be reported as “particulate”.

- **Determination of Total Elements**

  Acidify 100 ml of sample with 0,5 ml of nitric acid. Evaporate the mixture to near dryness, making sure that no area at the bottom of the beaker goes dry (a complete drying may lead to low results). In case of an incomplete digestion (undissolved material), add some water and repeat the treatment. Dissolve the residue in 1 ml of nitric acid (5.2) and some water and make up to 100 ml volume with water. Analyse the resulting solution per the method described in the General Section of Instrumental Method.

Calculation and Expression of Results

Subtract reagent blanks from all samples. This is quantities of acids to complete the digestion. particularly important for digested samples requiring large If dilutions were performed, apply the appropriate factor to the sample values. Report results in milligrams (or micrograms) of element per liter of sample and up to three significant figures.

3.1.2 Atomic absorption spectroscopy (AAS)

Atomic absorption spectroscopy (AAS) is an absorption spectroscopic method that uses the absorption of light by free atoms in a gaseous state to determine the quantitative composition of chemical components. It is used to determine the concentration of metals present in a sample to be analysed.

AAS can be used to quantify more than 70 different elements either in solution or solid form and possesses wider applications in clinical analysis, food analysis, the pharmaceutical industry, the mining sector, and so on. Because the atomic absorption method is largely free of interference and the set of electronic energy levels is specific to that element, it is a highly good analytical technique with great sensitivity.

The modern form of AAS was developed by Australian Chemist, Sir Alan Walsh in the 1950s.

Principle

Atomic Spectrophotometry depends on the fundamental capacity of atoms to either absorb or emit light. Atomic absorption spectrophotometry involves heating the atoms to a temperature that is sufficient to liberate them from solvents and prevent the formation of salts, while avoiding the excitation of electrons to higher energy levels. This is

Applications:

- **Mining and Geology:** AAS is used for the determination of the elemental composition of minerals and rocks of ores to assess the economic viability of mining operations in explored regions. It also helps in the trace metal analysis that holds significant importance in the exploration of oil and water reservoirs.
- **Environmental monitoring:** AAS plays crucial role in monitoring of trace metals pollution in industrial discharges, oceans, rivers, and typically achieved through the use of a flame or graphite tube. The unbound atomic entities, possessing electrons in their lowest energy level, are poised to assimilate radiation of precise

energy that would elevate the electrons to a higher electronic state.

The concentration of a specific atom in a given sample can be determined by measuring the amount of light it absorbs. This is due to the inverse relationship between the concentration of the atom and the amount of light that reaches the

- **lPahkaersmaceuticals and Medicine:** AAS helps in the development of drugs determin·,ation of catalyst efficiency, and establishment of dosage limits. Additionally, iron, manganese, copper, zinc, mercury, lead, and nickel can all be detected in human urine and blood.

- **Oil and petroleum:** AAS has role in refining of both edible oils and mineral oils prior to their consumption.

- **Food and beverages:** It is used for evaluating the concentrations of diverse elements in wine, beer, and fruit-based beverages. Also, identification of diverse forms of impurities present in food can be detected using AAS.

- **Forensic:** AAS finds application in forensics for analysing specimens, including stomach contents utilized for foodborne illness, investigations, paint chips, fibres, and hair strands that are gathered from the location of a criminal incident.

- **Agriculture:** Agriculture offer tremendous scope of application of AAS. It is used for the identification and quantification of metallic constituents, including but not limited to calcium, strontium, and cobalt, within soil samples. Analysis of animal feed in order to determine the presence of various elements such as Zn, Cu, Mn, Ca, K, Na, among others. Besides, analysis of animal-derived fertilizer in order to ascertain the levels of various elements, including but not limited to Ca, Cu, Mg, and Fe can also be accomplished using AAS.

Application in Indian Standards

Various Indian Standards have been developed that use ICP-AES and ICP-MS etc. for the determination of trace elements in soil samples, alloys, waste water treatment process, oils and fats samples, leather products etc. A comprehensive list of Indian Standards using various Atomic Emission Techniques are enumerated in Annexure 2. Further, IS 16721 (Part 1) : 2018 has been discussed below for reference.

Atomic Absorption Spectrometry Analysis Procedure

IS 16721 (Part 1) : 2018
Indian Standard
Method of Test for Coal
Part 1 Determination of Total Mercury Content by
Atomic Absorption Spectrometry

This standard prescribes the method for determination of total mercury content of coal by atomic absorption spectrometry (AAS).

Reagents

- General: All single element stock solutions of metal ions with concentration 1 000 ppm/100 ppm should be stored in polythene/polytetrafluoroethylene bottles with leak proof screw caps and labeled with the date of preparation. The stock solution shall not be used any longer than twelve months. Working and calibration standards are prepared step by step dilution of stock solution on the day before analysis.

- Quality of Reagents: Unless specified otherwise, pure chemicals and distilled water (see IS 1070) shall be employed in tests. NOTE — 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the results of analysis.

- Oxygen: Free from combustible matter and having minimum purity of 99.5 percent.

- Dilute Nitric Acid Solution: 10 percent (v/v). It is prepared by diluting 100 ml of concentrated nitric acid (relative density 1.42) to 1 litre with water. The 10 percent solution shall have mercury content less than 0.1 ìg/l.

- Mercury Standard Stock Solution: 1 000 ìg/ml. It is prepared by either of the following methods:

  a) Dissolve 1.080 g of mercury(II) oxide (HgO) in a minimum volume of 1:1 hydrochloric acid and dilute to 1 000 ml with water in a volumetric flask.

  b) Dissolve 1.352 0 g of mercury(II) chloride ($HgCl_2$) in water and dilute to 1 000 ml with water in a volumetric flask.

  c) Dissolve 1.0 g of mercury in 5 ml of 25 percent (v/v) nitric acid solution and dilute to 1 000 ml with water in a volumetric flask.

  NOTE — The mercury standard stock solution may also be prepared from commercially available certified mercury solution.

- Mercury Standard Solution — 0.1 ìg/ml It is prepared by diluting 5.0 ml of mercury standard stock solution (see 4.4) to 500 ml and then diluting 10.0 ml of the intermediate solution to 1 000 ml with water. This mercury standard solution shall be prepared on daily basis.

- Potassium Permanganate Solution — 50 g/l. It is prepared by dissolving 5 g of potassium permanganate ($KMnO_4$) in water and diluting to 100 ml with water. The mercury content of the potassium permanganate shall be below 0.05 ìg/g.

- Hydroxyl Ammonium Chloride Solution — 15 g/l. It is prepared by dissolving 1.5 g of hydroxyl ammonium chloride ($HONH3Cl$) in water and diluting to 100 ml with water. The mercury content of the hydroxyl ammonium chloride shall be below 0.005 ìg/g.
- Reducing Agent

  a) Stannous Chloride Solution — 100 g/l. It is prepared by dissolving 10 g of stannous chloride dehydrate ($SnCl2.2H2O$) in 45 ml of concentrated hydrochloric acid solution (relative density 1.19) and cautiously diluting to 100 ml with water. The mercury content of the stannous chloride dehydrate shall be below 0.01 ìg/g.

  b) Sodium Borohydride Solution Percent Weigh 1.50 g of sodium borohydride ($NaBH4$) and 0.4 g of sodium hydroxide ($NaOH$) into a plastic bottle of 125 ml capacity and add 100 ml of water. Prepare the solution freshly on the day of use. Alternatively, commercially available pressed pellets of sodium borohydride may be used. The mercury content of the sodium borohydride shall be below 0.01 ìg/g.

  NOTE — See also Note under 9.2 regarding the use of flow injection technique.

Preparation of Samples

The samples shall be received in sealed containers; air dried samples shall be ground such that at least 98 percent passes through a 75 ìm sieve. Care should be taken to avoid contamination during milling. Ensure that the moisture content of the sample is in equilibrium with the laboratory atmosphere, exposing it, if necessary, in a thin layer for the minimum time required to achieve equilibrium. Before commencing the determination, mix the equilibrated sample for at least 1 min, preferably by mechanical means.

Oxygen Bomb Combustion Procedure

General: Clean the internal components of the combustion bomb (the body, cap and the electrodes) by immersion in dilute nitric acid solution (see 4.3) for 5 min followed by thorough washing with water before use. Using paper towels, dry the threads on the combustion bomb body and locking ring. Repeat the washing step between each determination.

Combustion of Coal: Weigh approximately 1 g of test portion to the nearest 0.1 mg, into a pre-ignited crucible. Assemble the ignition system using ignition wire and ignition thread. Pipette 10 ml of water into the base of the combustion bomb and assemble. Charge the bomb with oxygen to 3 MPa pressure. Place the assembled combustion bomb in the calorimeter containing 2 litre of water and fire using the ignition/firing station. Allow the combustion bomb to stand in the calorimeter for 10 min before removal. Dry external surfaces of the bomb thoroughly with paper towel, keeping the bomb upright, before carefully venting the bomb gases over a period of 2 min.

Preparation Of Test Solution

Disassemble the combustion bomb and carefully rinse all internal surfaces, including the crucible, with water, collecting the washings in the bomb. Using a disposable syringe, transfer the bomb washings to a 100 ml volumetric flask containing 10 ml of dilute nitric acid solution (see 4.3). Wash the bomb with water, adding the washings to the volumetric flask. Add 0.5 ml of potassium permanganate solution (see 4.6) and mix. Dilute to volume with water.

Carry out a blank determination following exactly the procedure described above but omitting the coal sample.

ATOMIC ABSORPTION ANALYSIS

Calibration

Prepare matrix matched mercury standards of 3.0, 5.0, 10.0 µg/ml by pipetting 3.0, 5.0, 10.0 ml aliquot portions of the 0.1 µg/ml mercury standard solution into 100 ml graduated flasks, adding 10 ml of dilute nitric acid solution and diluting to volume with water. Add potassium permanganate solution dropwise to stabilize the solutions until the permanganate colour persists for 60 s.

Measure the absorbance for each matrix-matched solution. For instrument calibration, the absorbance for each matrix matched solution is plotted against the corresponding concentration. Sample response is compared with this calibration.

NOTE — An alternative quantification procedure is the use of standard analyte additions to the final solution.

Analytical Procedure

The calibration solutions prepared, and the test solutions and the blank solutions separated, are all treated as follows:

a) Transfer the prepared solution into a suitable mercury-free vessel and heat at 900°C for 60 min on a digestion block or water bath, cool.

b) Transfer the prepared solution into the reaction vessel; add 5 ml of hydroxyl ammonium chloride solution to the solution. When the permanganate colour fades, wait for 30 s and add 5 ml of the reducing agent, stannous chloride solution (see 4.8.1) or sodium borohydride solution.

c) Exact details of use of the instrumentation cannot be given as each instrument may be different. Depending on the instrumentation being used, it may be necessary to use the complete 100 ml prepared sample or an aliquot of the prepared sample. Whichever approach is used, samples, standards and blanks shall be treated in an identical manner.

d) Immediately connect the flask to the flameless cold-vapour atomic absorption spectrometer to complete the mercury determination. The spectrometer and the hydride generation apparatus are optimized according to the manufacturer’s advice. Mercury is measured at 253.7 nm.

e) The corresponding absorbance response for each test and blank solution is compared to the calibration curve and the resultant concentration, in µg/l, noted.

RESULTS

Calculate the mercury content, ù, expressed in µg/g of the sample as analyzed, using the following equation:

$$w \frac{p_t - p_b}{10xM} x\ 1000$$

where

p_t= mercury concentration of the test solution, in µg/l;

p_b = mercury concentration of the blank solution, in µg/l; and

M = mass of the sample as analyzed, in g.

Report the result as the mean of duplicate determinations to the nearest 20 µg/g on the ‘as analyzed’ basis.

UV-Visible Spectroscopy

UV-Visible Spectroscopy or Ultraviolet-visible spectroscopy or Ultraviolet-visible spectrophotometer (UV-Vis) is also called absorption spectroscopy or reflectance spectroscopy in the ultraviolet-visible spectral region.

UV-vis spectrometry is a powerful analytical technique used to study the absorption of ultraviolet (UV) and visible light by molecules. It operates on the principle that molecules absorb light at specific wavelengths, leading to the excitation of electrons to higher energy levels. By measuring the absorption of light at different wavelengths, UV-visible spectrometry provides valuable information about the structure, composition, and concentration of substances in a sample (Figure 3).

Electron transition takes place, so it is also called electron spectroscopy. It is a cost-effective, simple, versatile, and non-destructive technique that allows the sample to be used again for further analysis. It is a qualitative, quantitative, and analytical technique that compares a sample with a blank or reference sample to measure the amount of discrete ultraviolet and visible light absorbed or transmitted through a particular sample using Beer-Lambert law. It studies under vacuum conditions.

The wavelength of UV-vis spectroscopy ranges from 190 nm to 800 nm. The UV region ranges from 190 to 400 nm, and the visible region from 400 to 800 nm. Near UV region is 190 nm to 400 nm, and far UV region is below 200 nm. The shorter the wavelength, the higher will be the frequency and energy. It occurs in UV region. Similarly, the higher the wavelength, the lower the frequency and energy in the visible region.

Principle

The principle behind UV-visible spectrometry is based on the interaction between light and matter. When a molecule absorbs light, it undergoes a transition from a lower energy state to a higher energy state. This transition occurs when the energy of the incident light matches the energy difference between the ground state and an excited state of the molecule. The absorbed light energy is then converted into other forms of energy, such as heat or fluorescence.

The absorption of light by a molecule is quantified by measuring the decrease in the intensity of transmitted light through the sample. This decrease in intensity is proportional to the concentration of the absorbing species and follows Beer's law, which states that the absorbance (A) is directly proportional to the concentration (c) and the path length (l) of the sample, i.e., A = åcl, where å is the molar absorptivity or extinction coefficient.

Beer-Lambert Law equation is the principle behind absorbance spectroscopy.

The concentration of the sample can be determined directly from the absorption of spectra produced by these samples at specific wavelengths using the Beer-Lambert law.

Applications

- **DNA and RNA analysis:** It focuses on verifying the concentration and purity of DNA and RNA, which plays a crucial role in downstream applications like sequencing. It ensures whether the DNA or RNA samples prepared for sequencing are contaminant or pure. Since pure DNA has an absorbance ratio of 1.8 and pure RNA has a ratio of 2, the 260 nm/280 nm absorbance ratio is crucial for displaying protein contamination in nucleic acids. 260nm/230nm absorbance ratio varies for RNA and DNA (2.15 to 2.50).
- **Pharmaceutical analysis:** It is essential in drug discovery and development, quantifying impurities in drug ingredients, dissolution testing of solid oral dosage forms like tablets, and chemical identification and quantification. It allows overlapping absorbance peaks in the original spectra using mathematical derivatives to identify pharmaceutical compounds. Likewise, the identification of pharmaceutical compounds, Chlortetracycline (antibiotic) and benzocaine (anesthetic) in veterinary powder formulation, by overlapping the absorbance peaks in UV spectra using mathematical derivatives.
- **Food and Beverage Applications:** It applies to assessing the sensory attributes, nutritional components of food and its products such as beer, wine, juices, energy and soft drinks, waters, other thin liquids and thick liquids (honey, oils), fruits, vegetables, caffeine content, etc., and the chemical composition of ingredients and detect contaminants or adulterant to ensure the product is safe and healthier. It can be used in quality control in wine by identifying anthocyanin in blueberries, raspberries, and cherries. It can evaluate food and food product color, flavor, and aroma.
- **Bacterial culture:** It is essential in the biomass growth curve. It is used in culturing bacteria by estimating cell concentrations and growth tracking in measuring optical density at 600 nm. 600 nm is best to preserve the optical

properties of culture media where bacteria grow and to avoid cell damage when there is a need for continuous experimentation

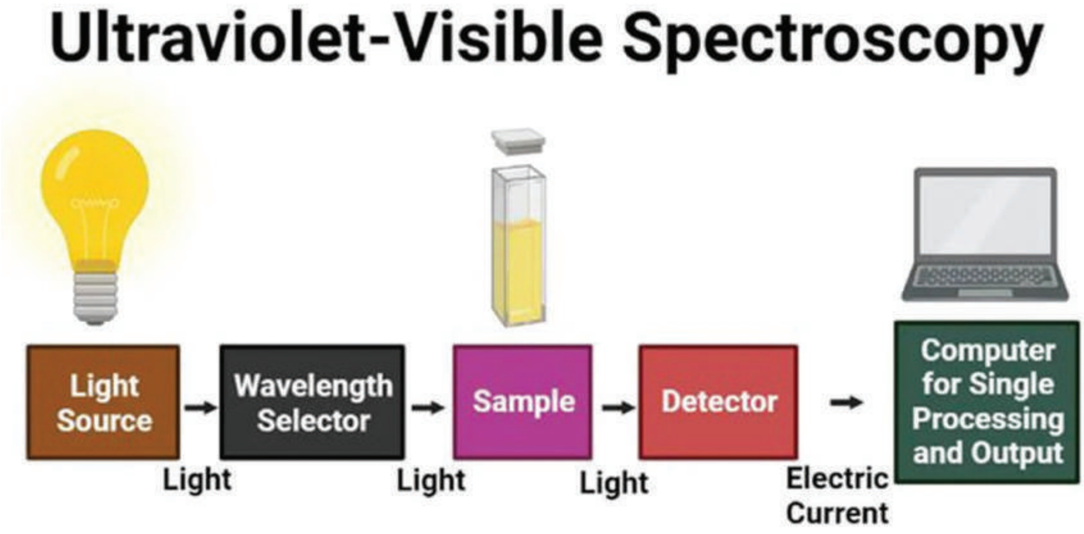


Figure 3 : Schematic Representation of UV-Vis Spectroscopy

Applications in Indian Standards

Atomic Absorption Spectroscopy finds application in different Indian Standards for sampling and testing for paper and allied products. It is also used for the determination of various metals such as sodium, potassium, copper, molybdenum, manganese, mercury, lead, nickel etc. in gasoline, soil samples and animal feeds.

Besides, chemical analyses of pig iron, cast iron, iron ores, hard metals, nickel alloys etc. are also based on the atomic absorption techniques. The various Indian Standards based on atomic absorption technique are listed in ***Annexure 2****.*

Standards have been developed to test the physical and chemical parameters of water and waste water and also for the determination of nitrate, nitrite, organic nitrogen and sulphide using UV- Visible Spectrometry. The details of such standards are listed in ***Annexure 3****.*

Further, IS 3025 (Part 24 / Sec 1) : 2022 has been discussed below for reference.

IS 3025 (Part 24/Sec 1): 2022

Methods of Sampling and Test (Physical and Chemical) for Water and Waste Water Part 24 Sulphates

UV Visible spectroscopy technique is used for the determination of compounds. Here an example of the determination of sulphates in waste water has been described as per IS 3025 (Part 24/Sec 1): 2022. This method is applicable to ground water, drinking and surface waters as well as domestic and industrial wastes. This method can be applied for all concentration ranges of sulphate; however readings are accurate for sample aliquots containing not more than 40 mg/l of SO_4^{2-}. The minimum detectable limit is approximately 1 mg/l SO_4^{2-}.

Principle

Sulphate ion is converted into barium sulphate suspension under controlled conditions. This suspension can be measured by using a nephelometer or spectrophotometer and light absorbance is measured at different concentrations; sample concentrations may be evaluated from standard curve.

Reagents

- Buffer Solution: Dissolve 30 g magnesium chloride ($MgCl_2.6H_2O$), 5g Sodium acetate ($CH_3COONa.3H_2O$), 1 g Potassium nitrate (KNO_3)and 20 ml acetic acid (CH_3COOH) in distilled water in a 500 ml volumetric flask and make up the volume to 1 000 ml.
- Standard Sulphate Solution: Dissolve 0.1479 g anhydrous Na_2SO_4 in distilled water and dilute to 1000 ml (1 ml = 100 ug SO_4^{2-}).
- Barium Chloride, crystals: 20 to 30 mesh.

Procedure

Preparation of Calibration Curve: Take 1.0 ml, 5.0 ml, 10.0 ml, 20.0 ml and 40.0 ml of the standard sulphate solution into 250 ml conical flasks and made up to the 100 ml mark with distilled water. Take 100 ml distilled water in a 250 ml flask for preparing distilled water blank. The concentration of the standards corresponding to 1.0 ml, 5.0 ml, 10.0 ml, 20.0 ml and 40.0 ml standard sulphate solution (1 ml = 100 ug SO_4^{2-}) are 100 ug (1 mg/l), 500 ug (5 mg/l), 1000 ug (10 mg/l), 2000 ug (20 mg/l) and 4000 ug (40 mg/l) respectively. Add 10 ml of buffer solution mix using magnetic stirrer. While stirring, add a spoonful of BaCl, crystals and note the timing immediately. Stir for 30 seconds at constant speed. After stirring has ended, pour the solution into absorbance cell and measure the turbidity at 420 nm against distilled water in 30 seconds interval for 5 minutes. Record the maximum reading obtained in the 5 min period. Obtain the corrected absorbance readings of the standard solutions by subtracting the absorbance readings of the standard solutions from that of distilled water blank. Plot the corrected absorbance readings of the standard solutions against concentrations.

Sample Analysis: 100 ml sample, or suitable portion made up to 100 ml is measured into a 250 ml conical flask. A distilled water blank is prepared by taking 100 ml distilled water in another 250 ml conical flask. Add 10 ml buffer solution and mix using magnetic stirrer. Follow the next procedures as done for standard solutions. Measure the absorbance reading of sample and distilled water blank against distilled water as reference. Obtain the corrected absorbance reading of sample by subtracting absorbance reading of distilled water blank from that of sample.

For samples having turbidity or colour, prepare a sample blank by taking 100 ml of the turbid or colured sample in a 250 ml conical flask. Add 10 ml of buffer solution (see 5.6.1) and take absorbance reading at 420 nm (without adding BaCl,) against distilled water as reference. The corrected absorbance reading of sample is obtained by subtracting the absorbance reading of distilled water blank and sample blank from the observed absorbance reading of sample.

Calculation

The concentration of sulphate (as SO_4^{2-}) in mg/l= $\frac{A \times 1000}{V \times k}$

Where,

A= corrected absorbance reading of sample;

k= slope from calibration curve; and

V= volume of sample taken (in ml).

If the sulphate content of sample is found to be greater than 10 mg/L, then repeat the sample analysis using buffer solution A. prepare a distilled water blank by using buffer solution A. Obtain the corrected absorbance reading of sample is obtained by subtracting absorbance reading of distilled water blank from absorbance reading of sample.

3.2 Chromatography

Chromatography is an important biophysical technique that enables the separation, identification, and purification of the components of a mixture for qualitative and quantitative analysis. The Russian botanist Mikhail Tswett coined the term chromatography in 1906.

The first analytical use of chromatography was described by James and Martin in 1952, for the use of gas chromatography for the analysis of fatty acid mixtures. A wide range of chromatographic procedures makes use of differences in size, binding affinities, charge, and other properties to separate materials. It is a powerful separation tool that is used in all branches of science and is often the only means of separating components from complex mixtures.

Principle:

Chromatography is based on the principle where molecules in mixture applied onto the surface or into the solid, and fluid stationary phase (stable phase) is separating from each other while moving with the aid of a mobile phase.

The factors effective on this separation process include molecular characteristics related to adsorption (liquid-solid), partition (liquid-solid), and affinity or differences among their molecular weights (Figure 4).

Because of these differences, some components of the mixture stay longer in the stationary phase, and they move slowly in the chromatography system, while others pass rapidly into the mobile phase, and leave the system faster.

Chromatography serves as a method employed to separate the constituents within a mixture. This separation hinges on several factors, including the velocity of movement, relative quantities, ionic configuration, and the bonding affinity of molecules or compounds.

Three components thus form the basis of the chromatography technique:

- **Stationary phase:** This denotes a substance or liquid applied to the surface of a solid phase.
- **Mobile phase:** This signifies a gas or liquid that traverses over the stationary phase.
- **Separated molecules**

The mobile phase, essentially a fluid in motion, acts as a solvent traversing through the stationary phase. The solid portion is termed the solute, while the liquid or fluid aspect is referred to as the solvent. Upon application of the mixture onto the solid surface, molecules within the stationary phase are carried along by the mobile phase fluid. The kinetic motion facilitates the exchange of solute molecules between the two phases. The characteristics such as adsorption (liquid-solid), partition (liquid-solid), and affinity or disparities in molecular weights govern the separation process. Some molecules exhibit faster migration rates, while others are retained for extended periods by the stationary phase. Components with higher molecular weights tend to linger in the stationary phase, whereas those with lower molecular weights move swiftly through the chromatogram. When the mobile phase is a liquid, the technique is labelled as liquid chromatography (LC), while if the mobile phase is gas, it is termed gas chromatography (GC). Liquid chromatography is commonly utilized for thermo-unstable and non-volatile samples, whereas gas chromatography finds application in gases and mixtures of volatile liquids and solid materials.

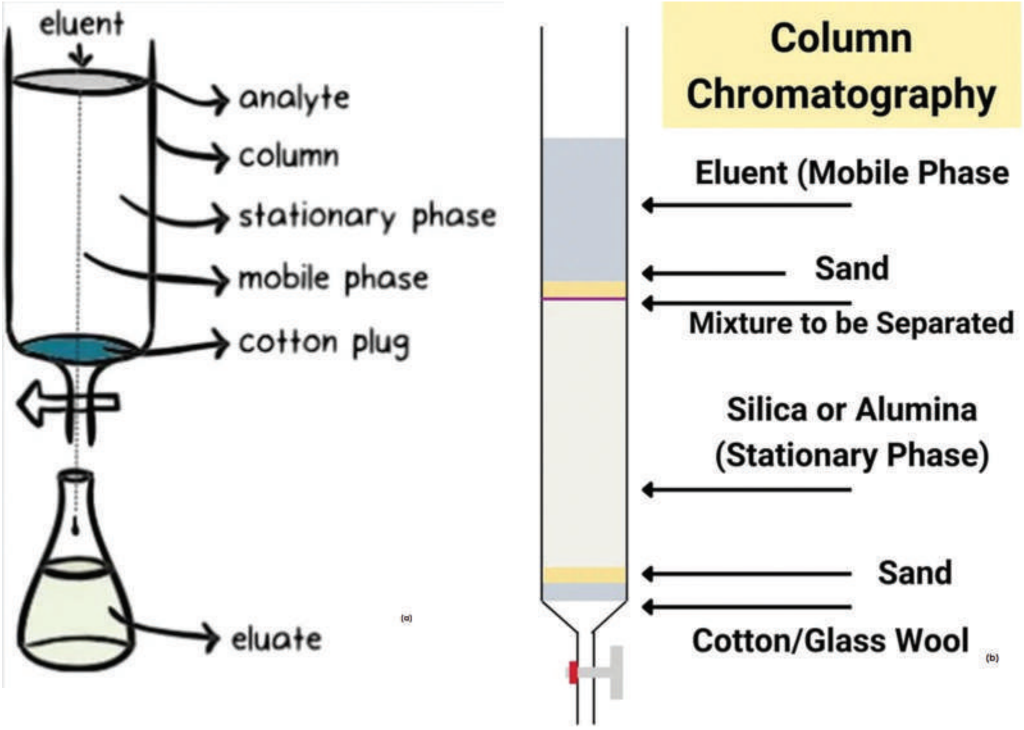


Figure 4: Schematic Representation of Chromatography, (b) Column Chromatography

Applications

- **Pharmaceutical sector:** The methods of chromatography finds application in identifying and analyzing samples for the presence of trace elements or chemicals. Besides it is used to separate compounds based on their molecular weight and element composition. It also detects the unknown compounds and purity of mixture and is ofetn used in drug development.
- **Chemical industry:** Chromatography is useful in testing water samples and also for checking air quality. HPLC (High Pressure LC) and GC are very much used for detecting various contaminants such as polychlorinated biphenyl (PCBs) in pesticides and oils.
- **Molecular Biology Studies:** Various techniques in chromatography such as EC-LC-MS are applied in the study of metabolomics and proteomics along with nucleic acid research. HPLC is used in Protein Separation like Insulin Purification, Plasma Fractionation, and Enzyme Purification and also in various departments like Fuel Industry, biotechnology, and biochemical processes.
- **Food Industry:** It finds application in food spoilage and additive detection and also for determining the nutritional quality of food.

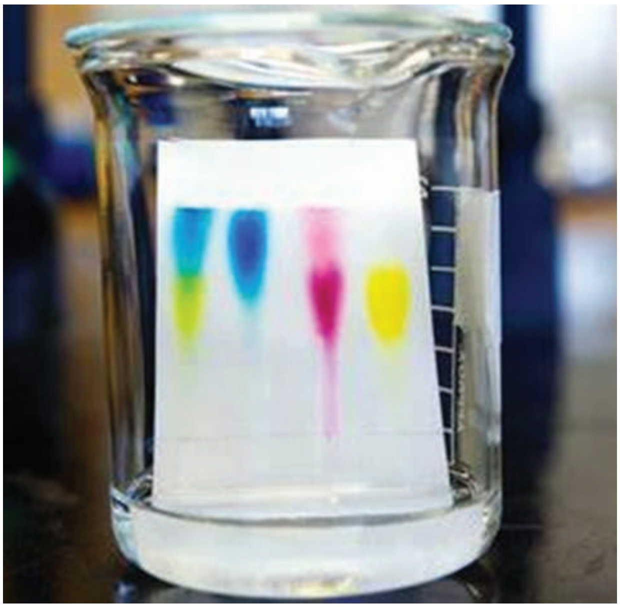


Figure: Paper Chromatography Setup

Applications in Indian StandardsApplications in Indian Standards

Chromatography is an important technique that finds tremendous application in various research and analytical sectors. The wide range of application of chromatography has been extensively used to develop Indian Standards for the Determination of Free and Total Carbohydrate Contents in instant coffee, Caffeine Content in tea and instant tea, Vitamin A, Vitamin E, Furazoli done content in animal feeds, Antibiotic Content, Colouring Agent sin meat and meat products, Organ onitrogen Compound sin Air, formaldehyde content and other chemical analyses of leather products and textile auxiliaries, Vitamin B12, Vitamin C, Vitamin D, nucleotides, myo-inositol in infant formula and adult nutritional and soon. The extensive list of Indian Standards using chromatography as a tool of analysis is given in ***Annexure 4.*** *Further, IS16028:2012*

ISO20481:2008 has been discussed below for reference.

Chromatography Analysis Procedure

IS 16028 : 2012
ISO 20481 : 2008
COFFEE AND COFFEE PRODUCTS —
DETERMINATION OF THE CAFFEINE CONTENT
USING HIGH PERFORMANCE LIQUID
CHROMATOGRAPHY (HPLC) —
REFERENCE METHOD

Chromatography, particularly high-performance liquid chromatography (HPLC) method has been used for the determination of the caffeine content of: green coffee; roasted coffee; soluble coffee, regular and decaffeinated; and mixed instant coffee products (e. g. coffee/chicory mix or cappuccino-type coffee drink).

Principle

Caffeine is extracted from samples with water at 90 °C in the presence of magnesium oxide. After filtration, the caffeine content of the extract is determined by HPLC on a RP-18 column using isocratic elution with UV detection at approximately 272 nm. Wherever appropriate, the caffeine content may be given on dry basis which requires a moisture determination by a suitable standard method.

Reagents

Unless otherwise specified, use only reagents of recognized analytical grade, and only water conforming to the requirements of ISO 3696, grade 1.

- Methanol, HPLC grade.
- Magnesium oxide (MgO), heavy, high grade 1).
- Caffeine (1,3,7-trimethylxanthine; 1,3,7-trimethyl-1H-purine-2,6(3H,7H)-dione; methyltheobromine; C8H10N4O2), pure anhydrous.
- Mobile phase, 24 % volume fraction methanol in water.
- Caffeine standard solutions.
    - Stock solution, corresponding to 200 mg/l. : Weigh 0,200 ± 0,001 g anhydrous caffeine and add into a 1 l one-mark volumetric flask. Add Sufficient warm water to half fill the flask, swirl to dissolve the caffeine, and cool to room temperature. Make up the volume to the mark with water and mix. The solution is stable at +4 °C for one month, subjected to be stored in a refrigerator.
    - Dilute standard solution for regular coffee, corresponding to approximately 40 mg/l. : Pipette out 50 ml of the caffeine standard stock solution to a 250 ml one-mark volumetric flask and make up the volume to the mark with water followed by mixing to prepare fresh dilute standard solution for single use.
    - Dilute standard solution for decaffeinated coffee, corresponding to approximately 4 mg/l.: Pipette out 5 ml of the caffeine standard stock

solution to a 250 ml one-mark volumetric flask and make up the volume is to the mark with water followed by mixing to prepare fresh dilute standard solution for single use.

- o Calibration plot: The use of a three-to-five-point calibration plot is optional. Recommended concentration range is 5 mg/l to 25 mg/l for regular coffee and 0,5 mg/l to 2,5 mg/l for decaffeinated samples.

Preparation of test samples

- Green coffee: Grind the green coffee beans so that more than 50 % mass fraction of the sample passes through the sieve. Then take the test sample from the well-mixed total ground coffee.
- Roasted coffee: Mill the roasted coffee beans so that more than 50 % mass fraction passes through the sieve. Roasted ground coffee in commercial packages without further treatment except homogenization may be used.
- Soluble coffee: Grinding of soluble coffee is not required.
- Mixed beverages: homogenize mixed coffee beverage powders using the mill immediately before extraction in order to prevent segregation.

Procedure

Test portion

- Roasted and green coffee: Weigh about 1 g of the test sample and transfer into a 250 ml volumetric flask.
- Instant coffee: Weigh about 0.5 g of the test sample and transfer into a 250 ml volumetric flask.
- Mixed beverages: Weigh about 1 g of the test sample and transfer into a 250 ml volumetric flask.
- Extraction of caffeine: Add the test portion, 5 g magnesium oxide and about 200 ml water in a flask and place in a water bath maintained at boiling point. Keep the apparatus there until the solution has reached at least 90 °C. Continue heating in the water bath for 20 min, with mixing by occasional shaking or stirring. Remove the volumetric flask from the water bath, cool to room temperature under tap water, and make up the volume with water. Rest the solution for the solids to settle down, following which take an aliquot of the supernatant solution, and filter through a 0.45 µm filter, after discarding the first few milliliters. The filtrate is now ready for the HPLC separation.

HPLC analysis

Degas the mobile phase for 20 min in the ultrasonic bath or purged with helium prior to use. If the HPLC equipment includes a degasser, 10 min are sufficient. Set the chromatograph in accordance with the manufacturer's instructions and adjust as following:

a) flow rate of the mobile phase: 1,0 ml/min;

b) UV detector set at 272 nm (or 254 nm in case of a filter detector). Ensure that the detector sensitivity range fits to the peak of the standard solution (in case of more than one standard to the peak of the highest one).

Analysis: Once the flow rate of the mobile phase and the corresponding pressure are stable, allow the system to equilibrate for at least 10 min. Then inject 10 µl of the standard solution onto the column, using the microliter syringe, in the next run followed by an equal volume of the sample extract. When a single standard solution is used, inject at regular intervals (typically after six sample extracts). After each batch of analysis, thoroughly flush the chromatographic system and column with 50 % volume fraction methanol and water. Replace the column sealing plugs if disconnected for storage.

Calculation

Caffeine content in the sample : Calculate the caffeine content, w_c, and expressed as a percentage by mass, numerically equivalent to grams per 100 g coffee as is, according to equation:

$$w_e = \frac{A_s p_{st} V \, x \, 100}{A_{st} m_s} = \frac{A_s p_{st} \, x \, 25}{A_{st} m_s}$$

Where,

A_{st} is the area, in arbitrary area units, of the HPLC caffeine peak of the caffeine standard solution;

A_s is the area, in arbitrary area units, of the HPLC caffeine peak of the sample solution;

m_s is the mass, in grams, of the test portion;

V is the volume, in litres, of the extracted sample solution (V = 0,25 l);

$\tilde{n}_{st}$ is the mass concentration, in grams per litre, of the caffeine standard solution.

3.3 Titration

Titration involves utilizing a solution with a known concentration to ascertain the concentration of an unknown solution. In this method, the titrant (the known solution) is incrementally added from a burette to a measured amount of the analyte (the unknown solution) until the reaction reaches completion. By determining the volume of titrant added, one can deduce the concentration of the unknown solution. Frequently, an indicator is employed to signify the conclusion of the reaction, known as the endpoint.

Principle

Titration involves the gradual addition of a reagent of known concentration, known as the titrant, to a solution whose concentration needs to be determined, known as the analyte. This process continues until stoichiometrically equivalent amounts of the reactants have been mixed, and an endpoint known as the equivalence point has been reached. The endpoint is typically indicated by a color change or other observable change, which signifies that the reaction between the analyte and titrant is complete. By carefully measuring and recording the volume of titrant required to reach this endpoint, along with its known concentration, it is possible to calculate the concentration or amount of analyte present in the original solution using stoichiometry and mathematical calculations (Figure 5).

Acid/base reaction

These involve the reaction of H+ or H3O+ with OH- to form H2O. They are the most common in both aqueous and nonaqueous media and are used every day in a wide range of applications:

- alkalinity determination in water,
- acid content in wine or fruit juice,
- acid content in milk,
- TAN and TBN in petroleum products,
- edible or inedible oils and fats,
- determination of boric acid in cooling fluids of nuclear power stations,
- determination of free or total acidity in plating baths,
- determination of active ingredients in drugs or raw materials for the pharmaceutical industry,
- total nitrogen determination using the Kjeldahl technique.

Redox reactions

As suggested by their name, these reactions leverage the reactivity inherent in the oxidizing/reducing pair. In this process, the oxidizing ion, whether it serves as the analyte or the titrant, undergoes reduction by acquiring one or more electrons, while the reducing ion undergoes oxidation, losing one or more electrons. While less frequent than acid/base reactions, these reactions encompass a broader array of titrants, including

Oxidising agents

- Iodine, potassium dichromate, potassium permanganate solutions.
- Cerium IV salts, hydrogen peroxide, oxidised chlorine, for example ClO-, ClO2

Primarily employed for assessing the concentration of divalent cations like calcium, magnesium, copper, lead, zinc, and cadmium, as well as other cations such as aluminium. The primary complexants utilized are ethylenediaminetetraacetic acid (EDTA) and ethylene bis (Oxyethynenitrilo) tetraacetic acid (EGTA). Despite their simplicity in execution, it's crucial to operate within a carefully defined pH range.

Application

- Total hardness of water (Ca2+ and Mg2+)
- Determination of Cu2+, Ni2+, Pb2+, Zn2+ in plating baths
- Determination of Ca2+ and Mg2+

Reducing agents

- Sodium thiosulphate solutions, oxalic acid, ammonium iron (II) sulphate (Mohr's salt), hydrogen peroxide, phenylarsine oxide (PAO).

Application

- COD of water
- Oxidation capacity of water by permanganate
- Determination of free and total SO2 in water, wine, alcohol, dried fruit etc.
- Vitamin C determination
- Titration of copper or tin using iodine
- Titration of chromium VI

Precipitation Reactions

Insoluble salts are common in nature and the most frequent use of precipitation reactions in analytical chemistry is the titration of halides, in particular Cl- by Ag+. The determination of the anions I-, Br- and Ag+ is also common.

Application

- Determination of chloride in water
- Determination of chloride in finished products (cooked meats)
- Determination of chloride in dairy products
- Determination of silver in various alloys (for jewellery)
- Titration of halides

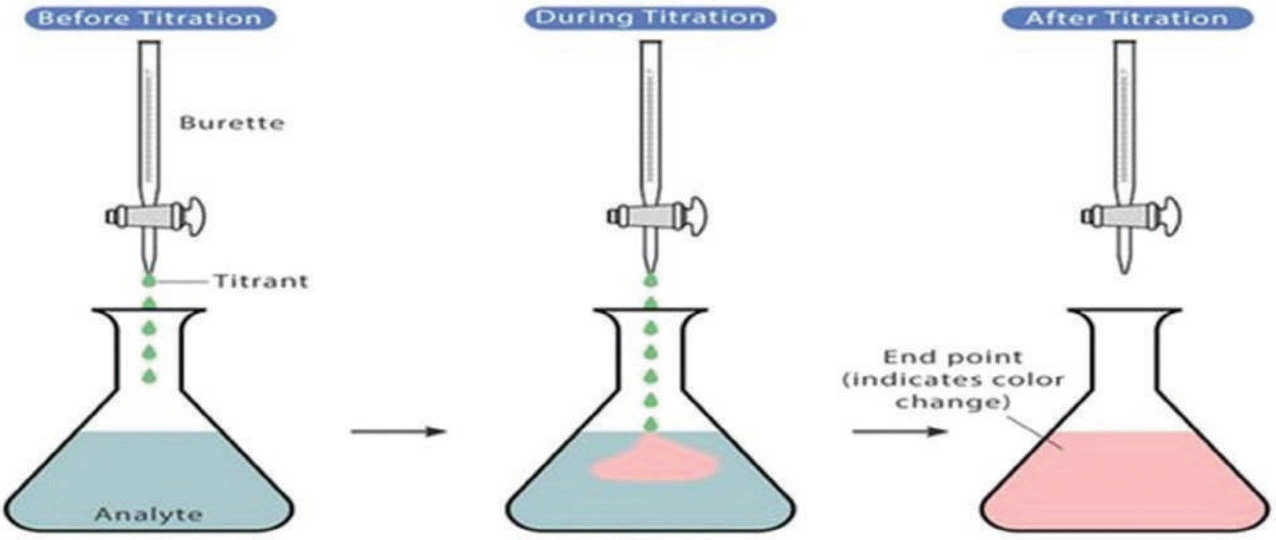


Figure 5: Pictorial Representation of Titration Procedure

Applications in Indian Standards

Titration is one of the fundamental analytical techniques that has been used in Indian Standards for the determination of Chlorine Residual in Packaged Drinking Water; Chloride, Iodine, Calcium & Magnesium in Iodized Salt, Vacuum Evaporated Iodized Salt and Refined Iodized Salt. It has also been used. Further, Annex-D of IS7224:2006 has been discussed below for reference.

Titration Based Analysis Procedure

Annex-D of IS 7224: 2006
Determination of Chloride in Iodized Salt,
vacuum evaporated iodized salt
and refined iodized salt

Titration technique finds application in Annex-D of IS 7224: 2006 for the determination of Chlorides in Iodized salt, vacuum evaporated iodized salt and refined salt.

REAGENT

For this, use standard 0.1 N silver nitrate solution with 5% potassium chromate indicator solution (1 ml).

PROCEDURE

Titrate the test solution against standard silver nitrate solution till the reddish-brown tinge persist after brisk shaking.

CALCULATION

The total chloride percentage by mass is calculated as

TCI (Total Chloride percentage by mass) =

V(volume in ml of silver nitrate solution x N (Normality of Silver Nitrate Solution)
M (Mass in gm of the dried sample in 1000 ml of test solution

3.4 Gravimetry Analysis

Gravimetry, the oldest of analytical techniques, includes all analytical methods in which the analytical signal is a measurement of mass or a change in mass. Since mass can be measured with greater accuracy than almost any other fundamental property, gravimetric analysis is among the most accurate classes of analytical methods available though they may be time intensive and tedious.

The three gravimetric methods commonly used in food analysis are:

- Thermogravimetry
- Precipitation Gravimetry
- Volatilization Gravimetry

They differ in the preparation of the sample before the mass of the analyte is determined.

Thermogravimctry

Samples are heated and changes in sample mass are recorded. Volatile analysis e.g. moisture content of foods in an important example. We use thermal energy to vaporize the water in the sample. To determine the amount of carbon in an organic compound, chemical energy of combustion is used to convert it to CO2. Typically, moisture content in food is determined via a thermogravimetric approach, i.e. by loss on drying, in which the sample is heated and the weight loss due to evaporation of moisture is recorded. Moisture content of food is a critical parameter and is among the most frequent thermogravimetry analysis carried out in a food analysis lab.

Precipitation Gravimctry

This technique relies on the chemical precipitation of an analyte. The precipitate is collected by filtration, washed, dried to remove traces of moisture from the solution, and weighed. The amount of analyte in the original sample is calculated from the mass of the precipitate and its chemical composition (Figure 6).

Volatilization Gravimetry

Volatilization gravimetry relies on separating a volatile component from a sample through heating, which converts it to a gas that is then weighed. This technique is particularly useful for substances that can be easily vaporized under controlled conditions.

Principles

Gravimetry is based on the fundamental principles of stoichiometry and mass conservation. The key principle behind gravimetric analysis is that the mass of an isolated compound can be used to calculate the amount of analyte present in the original sample.

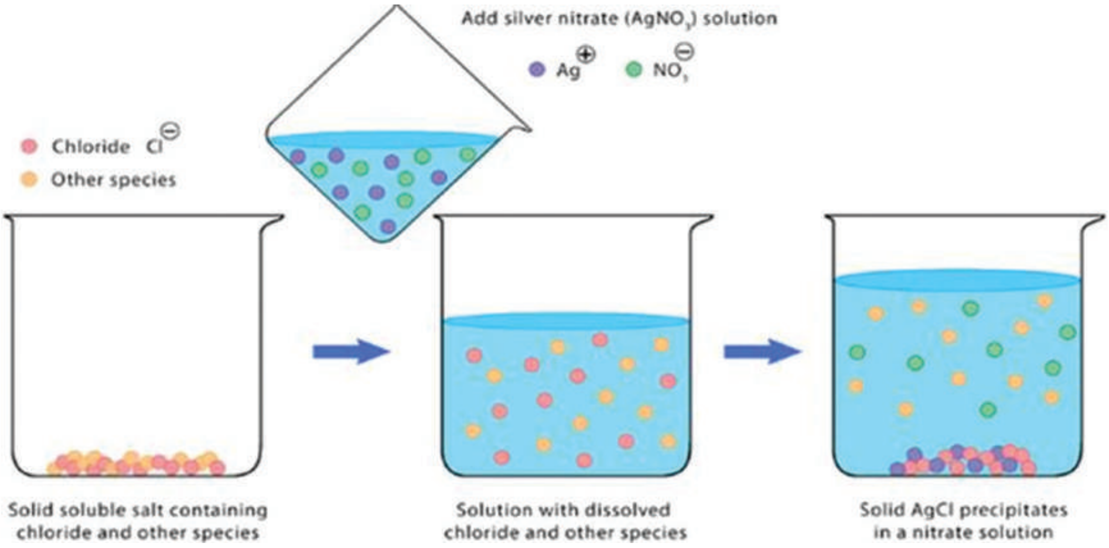


Figure 6: Pictorial Representation of Gravitametric Technique Procedure

Application

Gravimetric analysis is a powerful technique in analytical chemistry that offers several advantages in quantitative analysis. One of the key benefits of gravimetrical analysis is its high precision and accuracy in determining the quantity of a particular substance present in a sample. This method relies on measuring mass, making it reliable for obtaining precise results.

Another advantage of gravimetric analysis is its versatility and applicability to various compounds and elements. This technique can analyze organic and inorganic substances, making it a valuable tool for various industries such as pharmaceuticals, environmental monitoring, and materials science.

Applications in Indian Standards

Gravimetric techniques have been used in Indian Standards for the determination of insoluble matter in iodized salt, vacuum evaporated iodized salt and refined iodized salt. It is also used to quantify sulphates in caustic soda and relative density of sodium hypochlorite solution. ***Annexure 6*** *gives the detailed information on Indian Standards using gravimetric methods for analyses of various compounds. Further, Annex-B ofIS7224:2006 and IS 3025 (Part 24/ Sec1): 2022 and IS1473:2004 have been discussed below for reference.*

Gravimetric Analysis Procedure

Annex- B of IS 7224: 2006

Determination of Water Insoluble matter in Iodized Salt, vacuum evaporated iodized salt and refined iodized salt

Gravimetry technique finds application for the determination of Water Insoluble matter such as ferrocyanide in Iodized salt, vacuum evaporated iodized salt and refined salt as in the case of in Annex- B of IS 7224: 2006.

Reagents

Prepare ferrocyanide stock solution by dissolving 2.294 g of potassium ferrocyanide trihydrate, in water with addition of 5 ml of 0.1 N

Dilute potassium hydroxide and make the volume up to 1000 ml.

Prepare Ferrocyanide working solution by adding 5 ml of 0.1 N dilute potassium hydroxide into 25 ml of ferrocyanide stock solution and make the volume made up to 1000.

Boil the solutions, cool at room temperature and store in the dark.

Procedure

For the analysis, dissolve approx. 10 gm of salt in about 40 ml of water in a Nessler cynlinder graduated at 100 ml. Thereafter, add 10 ml of the dilute sulphuric acid and 5 ml pf ferrous/ ferric solution and mix well after each addition. Allow the solution to stand for about 2 mins and then add 35 ml pf phosphate solution, mix and make the volume up to 100 ml. The color of the solution should be less than or equal to potassium ferrocyanide solution prepared.

IS 1473:2004
INDIAN STANDARD
METHODS OF CHEMICAL ANALYSIS OF MANGANESE ORES
(FIRST REVISION)

Another area where, gravimetric methods are suitable is for determination of silica, barium oxide, manganese, iron, phosphorus, sulphur, alumina and other elements in manganese ores and concentrates.

Reagents:

- All reagents used shall be pure chemicals of analytical reagents grade, which do not contain impurities which would affect the analytical results
- The following standards contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standardsaresubjectto revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:
- Distilled water (see IS 1070) or de-ionised water shall be used in the preparation of reagents and throughout the analysis. All solutions shall be freshly prepared. The method of preparation of standard solutions shall be in accordance with IS 7659 (Part 1).

Procedure:

For determination of compounds, a glass petri dish with cover is dried in an air oven at 105+ 5^0C, cooled in a desiccator and weighed. 5 g of the ground sample (–100 micron size) is weighed and transferred to the petri dish. The cover is closed and the apparatus is heated in the air oven at 105 + 5°C to a constant mass (nearly 2 h of drying may be enough). The apparatus is then cooled in a desiccator and weighed. The correction factor (K) is calculated from the loss of mass as following (correct to four places of decimals). All weights shall be recorded to nearest 0.1 mg.

$$K = \frac{100}{100-A}$$

$$A = \frac{m2-m1}{m} \times 100$$

where,

m_1 = mass, ing,of the empty petri dish with cover (dried);

K = correction factor;

m_2 = mass, in g, of the petri dish with sample and cover after drying; and

m = mass, in g, of the sample, before drying.

CHAPTER IV

COMMON PRODUCTS EMPLOYING MORE THAN ONE ANALYTICAL TECHNIQUES

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COMMON PRODUCTS EMPLOYING MORE THAN ONE ANALYTICAL TECHNIQUES

Overview

Indian Standards on Test Methods cover analytical methods based on Spectroscopy, Chromatography, Titration based techniques and Gravimetric Methods. These all techniques are part of the curriculum and cover theoretical as well as practical aspects.

Some of the examples where these techniques are used are given blow:

a) Packaged Drinking Water as per IS 14543

Barium (as Ba), Copper (as Cu), Iron (as Fe), Manganese (as Mn), Zinc (as Zn), Silver (as Ag), Aluminium (as Al) etc are quantified using Inductively Coupled Plasma - Optical Emission Spectrometry (ICP-OES) or Inductively Coupled Plasma - Mass Spectrometry (ICP-MS) or Atomic Absorption Spectroscopy (AAS). Bromate (as $BrO3$) is quantified using Ion Chromatography. Chloride (as Cl), Alkalinity (as $HCO3$) and Residual Free Chlorine is determined by Titration. Sulphate (as $SO4$) is determined by Gravimetric Method.

b) Iodized Salt as per IS 7224:2006

Vacuum evaporated iodized salt and Refined Iodized Salt, Lead (as Pb) is determined by using Atomic Absorption Spectroscopy (AAS). Chloride content (as NaCl), Calcium (as Ca), Magnesium (as Mg), Iodine Content and Alkalinity (as $Na2CO3$) is determined by using Titration Technique, Water Insoluble Matter and Sulphate (as $SO4$) are determined using Gravimetric Technique.

c) Sodium Hypochlorite Solution used for Water Treatment

Lead (as Pb), Arsenic (as As), Mercury (as Hg), Manganese (as Mn), Total Chromium (as Cr), Cadmium (as Cd) and Selemim (as Se) are determined by using Inductively Coupled Plasma - Optical Emission Spectrometry (ICP- OES) or Inductively Coupled Plasma - Mass Spectrometry (ICP-MS) or Atomic Absorption Spectroscopy (AAS). Available Chlorine (as Cl_2), Total Chlorine (as Cl_2), Free Alkali (as $NaOH$) and Free Sodium Carbonate (as Na_2CO_3) are determined by using Titration Technique. Relative Density is determined using Gravimetric Technique.

CHAPTER V

ANNEXURES LIST OF RELEVANT INDIAN STANDARDS

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ANNEXURES LIST OF RELEVANT INDIAN STANDARDS

Annex-I

Indian Standard on Test Methods using Atomic Emission Techniques

S. No	IS No.	IS Title	Scope/Brief Description
1	IS 17379: 2020 ISO 20647:2015	Infant Formula and Adult Nutritionals " Determination of Total Iodine Inductively Coupled PlasmaMass Spectrometry (ICP-MS)	This standard specifies the method for determining total iodine content in infant formula and adult nutritional products using ICP-MS.
2	IS 17835: 2022 ISO 23156:2021	Ferronickels: Determination of phosphorus manganese chromium copper and cobalt contents inductivelycoupled plasma atomic emission spectrometric method	This standard provides a method for analyzing ferronickel samples to determine the content of phosphorus, manganese, chromium, copper, and cobalt using ICP-AES.
3	IS 18116: 2023 ISO/TS 13278: 2017	Nanotechnologies Determination of elemental impurities in samples of carbon nanotubes using inductively coupled plasma mass spectrometry	This standard outlines the procedure for detecting elemental impurities in carbon nanotubes utilizing ICP-MS technology.
4	IS 18242: 2023 ISO 22036	Soil quality Determination of trace elements inextracts of soil by inductively coupled plasma-atomic emission spectrometry ICP-AES	This standard describes a method for determining trace elements in soil extracts using ICP-AES to ensure soil quality.
5	IS 2600 (Part 5): 2022	Method of chemical analysis of zinc and zinc base alloys for die casting (Part 5) : Analysis by inductively coupled plasmaemission spectrometry	This part of the standard specifies the procedure for analyzing zinc and zinc-based alloys for die casting using ICP emission spectrometry.
6	IS 3025 (Part 2): 2019 ISO 11885:2007	Methods of sampling and test (Physical and Chemical) for water and wastewater: Part 2 determination ofselected elements by inductively coupled plasma optical emission spectrometry (Icp - Oes)	This standard outlines the method for determining selected elements in water and wastewater samples using ICP-OES.

S. No	IS No.	IS Title	Scope/Brief Description
7	IS 3025 (Part 64) :2015 ISO 17294-1: 2004	Methods of sampling and test (Physical and Chemical) for water and wastewater: Part 64 application of inductively coupled plasma mass spectrometry (ICP - MS) - General guidelines	This part provides general guidelines for using ICP-MS in the analysis of water and waste water samples.
8	IS 3025(Part 65): 2022 ISO 17294-2: 2016	Methods of Sampling and Test Physical and Chemical for Water and Wastewater Part 65 Application of Inductively Coupled Plasma Mass Spectrometry (ICP-MS) — Determination of selected elements including Uranium Isotopes	This standard specifies the method for determining selected elements, including uranium isotopes, in water and waste water using ICP-MS.
9	IS 548(Part 3/ Sec 8): 2021ISO 10540-3: 2002	Methods Of Sampling and Test For Oils and Fats Part 3 Advanced Instrumental Methods Section 8 Determination Of Phosphorus Content by Method Using Inductively Coupled Plasma Icp Optical Emission Spectroscopy (Adoption of Iso 10540-3: 2002)	This section of the standard describes the method for determining the phosphorus content in oils and fats using ICP-OES.
10	IS 582 (Part 10/ Sec 4):2022 ISO 5398-4: 2018	Methods of Chemical Testing of Leather Part 10 Determination of chromic oxide content Section 4 Quantification by inductively coupled plasma ICP	This standard outlines the method for quantifying chromic oxide content in leather using ICP technology

Annex-II

Indian Standard on Test Methods using Atomic Absorption Techniques

S. No	IS No.	IS Title	Scope/Brief Description
1	IS 1060 (Part4/ Sec 12):2019 ISO 10775; 2013	Methods of sampling and test for paper and allied products: Part 4 methods of test for paper, board and pulps: Sec 12 determination ofcadmium content - Atomic absorption spectrometric method	This standard specifies the method for determining cadmium content in paper, board, and pulp samples using atomic absorption spectrometry.
2	IS 10614: 1983	Method for atomic absorption spectrophotometric determination of sodium and potassium	This standard describes the procedure for determining sodium and potassium levels using atomic absorption spectrophotometry.
3	IS 11123: 1984	Method for determination of copper by atomic absorption spectrophotometry	This standard provides a method for determining copper content in various samples using atomic absorption spectrophotometry.
4	IS 11124: 1984	Method for atomic absorption spectrophotometric determination of arsenic	This standard outlines the procedure for determining arsenic levels using atomic absorption spectrophotometry.
5	IS 12041: 1987	Method for the determination of mercury by atomic absorption spectrophotometer	This standard specifies the method for determining mercury content in samples using an atomic absorption spectrophotometer.
6	IS 12042: 1987	Method for determination of molybdenum by atomic absorption spectrophotometer	This standard describes the procedure for determining molybdenum content using atomic absorption spectrophotometry.
7	IS 12046: 1987	Method for the determination of manganese by atomic absorption spectrophotometer	This standard outlines the method for determining manganese levels in samples using atomic absorption spectrophotometry.
8	IS 12074: 1987	Method for determination of lead by atomic absorption spectrophotometer	This standard specifies the procedure for determining lead content in samples using atomic absorption spectrophotometry.

S. No	IS No.	IS Title	Scope/Brief Description
9	IS 12107 (Part 10):2001	Methods of chemical analysis of alumino - Silicate refractory materials: Part 10 determination of iron manganese, calcium and magnesium by atomic absorption spectrometric method	This standard describes the methods for determining the content of iron, manganese, calcium, and magnesium in alumino- silicate refractory materials using atomic absorption spectrometry.
10	IS 12122: 1987	Method for determination of nickel by atomic absorption spectrophotometry	This standard provides the method for determining nickel content in samples using atomic absorption spectrophotometry.
10	IS 12122:1987	Method for determination of nickel by atomic absorption spectrophotometry	This standard provides the method for determining nickel content in samples using atomic absorption spectrophotometry.
11	IS 12308 (Part 12):1992	Methods for Chemical Analysis of Cast Iron and Pig Iron: Part 12 Determination of copper by atomic absorption spectrometric method (for copper 0.01 to 0.5 percent)	This standard outlines the method for determining copper content in cast iron and pig iron using atomic absorption spectrometry, applicable for copper content from 0.01 to 0.5 percent.
12	IS 12308 (Part 13):1992	Methods of chemical analysis of castiron and pigiron: Part 13 determination of magnesium by atomic absorption spectrometric method (For Magnesium Upto 0.1 Percent)	This standard specifies the procedure for determining magnesium content in cast iron and pig iron using atomic absorption spectrometry, for magnesium up to 0.1 percent.
13	IS 12473 (Part 1):1988	Chemical analysis of hardmetals by flame atomic absorption spectrometry: Part 1 general requirements	This standard provides general requirements for the chemical analysis of hardmetals using flame atomic absorption spectrometry.
14	IS 12473 (Part 2):1988	Chemical Analysis of Hardmetals by Flame Atomic Absorption Spectrometry- Part 2 : Determination of Calcium, Potassium, Magnesium and Sodium in Contents from 0	This part of the standard describes the determination of calcium, potassium, magnesium, and sodium in hardmetals using flame atomic absorption spectrometry.
15	IS 12473 (Part 3) :1988	Chemical analysis of hardmetals by flame atomic absorption spectrometry: Part 3 determination of cobalt,	This standard outlines the method for determining cobalt, iron, manganese, and nickel in hardmetals using flame atomic

S. No	IS No.	IS Title	Scope/Brief Description
		iron, manganese and nickel in contents from0.01 to 0.5 percent (M/m)	absorption spectrometry, for contents from 0.01 to 0.5 percent.
16	IS 12473 (Part 4):1988	Chemical analysis of hardmetals by flame atomic absorption spectrometry: Part 4 determination of molybdenum, titanium and vanadium in contents from 0.01 to 0.5 percent (M/m)	This standard describes the procedure for determining molybdenum, titanium, and vanadium in hardmetals using flame atomic absorption spectrometry, for contents from 0.01 to 0.5 percent.
17	IS 12473 (Part 5):1988	Chemical analysis of hardmetals by flame atomic absorption spectrometry: iron, Part 5 determination ofcobalt, manganese, molybdenum, nickel, titanium and vanadium in contents from 0.5 to 2 percent (M/m)	This standard outlines the method for determining cobalt, iron, manganese, molybdenum, nickel, titanium, and vanadium in hardmetals using flame atomic absorption spectrometry, for contents from 0.5 to 2 percent.
18	IS 12473 (Part 6):1988	Chemical analysis of hardmetals by flame atomic absorption spectrometry: Part 6 determination of chromium in contents from 0.01 to 2percent (M/m)	This standard specifies the procedure for determining chromium content in hardmetals using flame atomic absorption spectrometry, for contents from 0.01 to 2 percent.
19	IS 12491 :1988	Method for determination of magnestum by atomic absorption spectrophotometry	This standard outlines the method for determining magnesium content in samples using atomic absorption spectrophotometry.
20	IS 12760 : 2012 ISO8070: 2007	Milk and milk products - Determination of calcium, sodium, potassium and magnesium contents - atomic absorption spectrometric method	This standard describes the procedure for determining the content of calcium, sodium, potassium, and magnesium in milk and milk products using atomic absorption spectrometry.
21	IS 12813:1989	Method Of Analysis Of Hydraulic CementBy Atomic Absorption Spectrophotometer	This standard specifies the method for analyzing hydraulic cement using atomic absorption spectrophotometry.
22	IS 13319:1992	Determination of chromium by atomic absorption spectro-photometry test method	This standard outlines the procedure for determining chromium content in samples using atomic absorption spectrophotometry.

S. No	**IS No.**	**IS Title**	**Scope/Brief Description**
23	IS 13320:1992	Determination of iron by atomic absorption spectrophotometry - Test method	This standard describes the method for determining iron content in samples using atomic absorption spectrophotometry.
25	IS 1448 (Part 145):2022	Methods of test for petroleum and its products Part 145 Determination of sodium nickel and vanadium in fuel oils and crude oils by atomic absorption spectroscopy (first revision)	This standard describes the procedure for determining sodium, nickel, and vanadium content in fuel oils and crude oils using atomic absorption spectroscopy.
26	IS 14644(Part 1) : 2020 ISO 7530-1 :2015	Nickel Alloys — Flame Atomic Absorption Sepctrometric Analysis Part 1 Determination of Cobalt, Chromium, Copper, Iron and Manganese	This standard outlines the method for determining cobalt, chromium, copper, iron, and manganese in nickel alloys using flame atomic absorption spectrometry.
27	IS 14644(Part 7) : 2000 ISO 7530 -7:1992	Nickel alloys - Flame atomic absorption spectrometric analysis - Method: Part 7 determination of aluminium content	This standard specifies the procedure for determining aluminum content in nickel alloys using flame atomic absorption spectrometry.
28	IS 14644(Part 8) : 2000 ISO 7530-8:1992	Nickel alloys - Flame atomic absorption spectrometric analysis - Method: Part 8 determination of silicon content	This standard outlines the method for determining silicon content in nickel alloys using flame atomic absorption spectrometry.
29	IS 14644(Part 9) :2000 ISO 7530-9:1993	Nickel alloys - Flame atomic absorption spectrometric analysis - Method: Part 9 determination of vanadium content	This standard describes the procedure for determining vanadium content in nickel alloys using flame
30	IS 1493 (Part 3):1987	Methods of chemical analysis of iron ores: Part 3 determination of titanium, chromium, vanadium, calcium and magnesium by atomic absorption spectrophotometry	Describes methods for determining titanium, chromium, vanadium, calcium, and magnesium content in iron ores using atomic absorption spectrometry.
31	IS 1493 (Part 4):1988	Methods of chemical analysis of iron ores: Part 4 determination of aluminium by atomic absorption spectrophotomety	Specifies procedure for determining aluminium content in iron ores using atomic absorption spectrophotometry.

S. No	IS No.	IS Title	Scope/Brief Description
32	IS 1493(Part 5): 2020 ISO 5418-2:2006	Methods of Chemical Analysis of Iron Ores Part 5 Determination of Copper Content — Flame Atomic Absorption Spectrometric Method	Outlines method for determining copper content in iron ores using flame atomic absorption spectrometry
33	IS 1493(Part 6): 2020 ISO 13313: 2017	Methods of Chemical Analysis of Iron Ores Part 6 Determination of Sodium Content— Flame Atomic Absorption Spectrometric Method	Describes procedure for determining sodium content in iron ores using flame atomic absorption spectrometry.
34	IS 1493(Part 7): 2022 ISO 13311: 1997	Methods of chemical analysis of iron ores – Part 7 Determination of Lead Content-Flame Atomic Absorption Spectrometric Method (Second Revision)	Specifies method for determining lead content in iron ores using flame atomic absorption spectrometry.
35	IS 1493(Part 9): 2020 ISO 13312:2017	Methods of Chemical Analysis of Iron Ores Part 9 Determination of Potassium Content â•” Flame Atomic Absorption Spectrometric Method	Outlines method for determining potassium content in iron ores using flame atomic absorption spectrometry.
36	IS 1493(Part 10) : 2022 ISO 13310:1997	Methods of chemical analysis of iron ores-Part 10 Determination of Zinc Content-Flame Atomic Absorption Spectrometric Method	Describes procedure for determining zinc content in iron ores using flame atomic absorption spectrometry.
37	IS 15121: 2002 ISO6869	Animal feeding stuffs - Determination of the contents of calcium, copper, iron, magnesium, manganese, potassium, sodium and zinc - Method using atomic absorption spectrometry	Provides method for determining calcium, copper, iron, magnesium, manganese, potassium, sodium, and zinc contents in animal feeding stuffs using atomic absorption spectrometry.
38	IS 15302:2003	Determination Of Aluminium and Barium in Water by Direct Nitrous Oxide - Acetylene Flame AtomicAbsorption Spectrometry	Specifies method for determining aluminium and barium content in water using direct nitrous oxide-acetylene flame atomic absorption spectrometry.
39	IS 15303:2003	Determination of Antimony, Iron And Selenium In Water By Electrothermal Atomic Absorption Spectrometric Method	Describes procedure for determining antimony, iron, and selenium content in water using electrothermal atomic absorption spectrometry.

S. No	IS No.	IS Title	Scope/Brief Description
40	IS 15309 :2003 ISO8518:2001	Workplace air- Determination of particulate lead and lead compounds - Flame or electro-thermal atomic absorption spectrometric method	Outlines method for determining particulate lead and lead compounds in workplace air using flame or electrothermal atomic absorption spectrometry.
41	IS 16618:2017	Determination of ten race elements in coal, coke, lignite and fly ash by flame atomic absorption spectroscopic method	Specifies method for determining ten trace elements in coal, coke, lignite, and fly ash using flame atomic absorption spectroscopy.
42	IS 16721 (Part 1):2018	Method of test for coal: Part 1 determination of total mercury content by atomic absorption spectrometry	Describes method for determining total mercury content in coal using atomic absorption spectrometry.
43	IS 16721 (Part 2):2018	Method of Test for Coal: Part 2 Determination of Arsenic and Selenium - Eschka's Mixture and Hydride Generation/ Atomic Absorption Spectrometry	Specifies procedure for determining arsenic and selenium content in coal using Eschka's mixture and hydride generation/atomic absorption spectrometry.
44	IS 16913:2018	Methods of test for cosmetics - Determination of heavy metals (Arsenic, Cadmium, Lead AndMercury) by atomic absorption spectrometry (Aas)	Outlines method for determining heavy metal content (arsenic, cadmium, lead, mercury) in cosmetics using atomic absorption spectrometry.
45	IS 17325 :2020 ISO7520: 1985	Ferronickel Determination of Cobalt Content Flame Atomic Absorption Spectrometric Method	Describes method for determining cobalt content in ferronickel using flame atomic absorption spectrometry.
46	IS 17378:2021	Test method for determination of major elements in coal and coke ash by flame atomic absorption spectroscopic method	Specifies procedure for determining major elements in coal and coke ash using flame atomic absorption spectroscopy.
47	IS 17835: 2022 ISO23156: 2021	Ferronickels Determination of phosphorus manganese chromium copper and cobalt contents Inductively coupled plasma atomic emission spectrometric method	Outlines method for determining phosphorus, manganese, chromium, copper, and cobalt contents in ferronickels using inductively coupled plasma atomic emission spectrometry.

S. No	**IS No.**	**IS Title**	**Scope/Brief Description**
48	IS 18222: 2023 ISO1776:1985	Glass - Resistance to attack by hydrochloric acid at 100oC - Flame emission or flame atomic absorption spectrometric method	Specifies method for determining resistance of glass to hydrochloric acid at 100°C using flame emission or flame atomic absorption spectrometry.
49	IS 18238: 2023 ISO11047:1998	Soil quality Determination of cadmium chromium cobalt copper lead manganese nickel and zinc in aqua regia extracts of soil Flame and electrothermal atomic absorption spectrometric methods	Describes procedure for determining cadmium, chromium, cobalt, copper, lead, manganese, nickel, and zinc in aqua regia extracts of soil using flame and electrothermal atomic absorption spectrometry.
50	IS 18239: 2023 ISO16772: 2004	Soil quality Determination of mercury in aqua regia soil extracts with cold-vapour atomic spectrometry or cold-vapour atomic fluorescence spectrometry	Outlines method for determining mercury in aqua regia soil extracts using cold-vapour atomic spectrometry or cold-vapour atomic fluorescence spectrometry.
51	IS 18241 :2023 ISO20280:2007	Soil quality Determination of arsenic antimony and selenium in aqua regia soil extracts with electrothermal or hydride- generation atomic absorption spectrometry	Specifies procedure for determining arsenic, antimony, and selenium in aqua regia soil extracts using electrothermal or hydride-generation atomic absorption spectrometry.
52	IS 1917 (Part 4):1991	Chemical analysis of quartzite and high silica sand: Part 4 determination of aluminium by atomic absorption spectrometric method	Describes method for determining aluminium content in quartzite and high silica sand using atomic absorption spectrometry.
53	IS 1917 (Part 5):1992	Chemical analysis of quartzite and high silica sand: Part 5 determination of iron by atomic absorption spectrometric method	Outlines procedure for determining iron content in quartzite and high silica sand using atomic absorption spectrometry.
54	IS 1917 (Part 6):1992	Chemical analysis of quartzite and high silica sand: Part 6 determination of calcium and magnesiumby atomic absorption spectrometric method	Specifies method for determining calcium and magnesium content in quartzite and high silica sand using atomic absorption spectrometry.
55	IS 2000 (Part 8):1989	Chemical analysis of bauxite: Part 8 determination of	Describes method for determining manganese

S. No	IS No.	IS Title	Scope/Brief Description
		manganese by atomic absorption spectrophotometric method	content in bauxite using atomic absorption spectrophotometry
56	IS 2000 (Part 9):1989	Chemical analysis of bauxite: Part 9 determination of magnesium and calcium by atomic absorption spectrophotometric method	Outlines procedure for determining magnesium and calcium content in bauxite using atomic absorption spectrophotometry.
57	IS 2600 (Part 2):1988	Methods of chemical analysis of zinc and zinc base alloys for die castings: Part 2 determination ofcopper, iron, lead and cadmium by atomic absorption spectrophotometric method	This standard specifies the methods for determining copper, iron, lead, and cadmium in zinc and zinc base alloys for die castings using atomic absorption spectrophotometry.
58	IS 2600 (Part 3):1993	Methods of chemical analysis of zinc and zinc base alloys for die castings: Part 3 determination of indium by atomic absorption spectrometric method	This standard outlines the method for determining the indium content in zinc and zinc base alloys for die castings through atomic absorption spectrometry.
59	IS 2600 (Part 6):2022	Methods of Chemical Analysis of Zinc and Zinc Base Alloys for Die Castings (Part6) : Determination of Magnesium by Atomic Absorption Spectrometric Method (First Revision)	This standard details the procedure for determining magnesium in zinc and zinc base alloys for die castings by atomic absorption spectrometry.
60	IS 4027 (Part 9):1991	Methods of chemical analysis of bronzes: Part 9 determination of aluminium by atomic absorptionspectrometric method	This standard specifies the method for determining the aluminium content in bronzes using atomic absorption spectrometry.
61	IS 548 (Part3/ Sec 7):2021 ISO 10540-2: 2003	Methods of Sampling and Test For Oils and Fats Part 3: Advanced Instrumental Methods Section 7 Determination of Phosphorus Content by Graphite Furnace Atomic Absorption Spectrometric Method	This standard defines the method for determining the phosphorus content in oils and fats by graphite furnace atomic absorption spectrometry.
62	IS 582 (Part10/ Sec 3) :2022 ISO	Methods of Chemical Testing of Leather Part 10 Determi-	This standard specifies the method for determining the

S. No	IS No.	IS Title	Scope/Brief Description
	5398-3:2018	nation of Chromic Oxide Content Section 3 Quantification by Atomic AbsorptionSpectrometry	chromic oxide content in leather using atomic absorption spectrometry.
63	IS 9958:1981	Atomic Absorption Spectrophotometric Method For Determination of Zinc	This standard outlines the atomic absorption spectrophotometric method for determining the zinc content in various samples.

Annex-III

Indian Standard on Test Methods using UV-Visible Spectrometry Techniques

S. No	IS No.	IS Title	Scope/Brief Description
1	IS 3025 (Part24/ Sec 1): 2022	Methods Of Sampling And Test (Physical And Chemical) For Water And Waste Water Part 24 Sulphates Section 1 Gravimetric And Turbidity Methods	This standard specifies the methods for determining sulphates in water and wastewater using gravimetric and turbidity methods.
2	IS 3025 (Part34/ Sec 1): 2023	Methods of Sampling and Test (Physical and Chemical) for Water and Wastewater Part 34 Nitrogen Section 1 Determination of Various Types of Nitrogen Like Ammonical, Nitrate, Nitrite and Organic Nitrogen (Second Revision)	This standard outlines the methods for determining various types of nitrogen, including ammoniacal, nitrate, nitrite, and organic nitrogen, in water and wastewater.
3	IS 3025 (Part 29) :2022	Methods of Sampling and Test (Physical and Chemical) for Water and Waste Water Part 29 Sulphide	This standard specifies the methods for determining sulphide in water and wastewater samples.

Annex-IV

Indian Standard on Test Methods using Chromatography Techniques

S. No	IS No.	IS Title	Scope/Brief Description
1	IS 1448 (Part 104):1981	Method of Test for Petroleum and its Products (Part 104) Aromatics in Light Naphthas And Aviation Gasolines by Gas Chromatography	This standard specifies the method for determining the concentration of aromatics in light naphthas and aviation gasolines using gas chromatography.
2	IS 1448 (Part 111):1983	Methods of Test for Petroleum And Its Products [P:111] Analysis Of Liquefied Petroleum Gases (LPG) And Propylene Concentrates By Gas Chromatography	This standard outlines the procedure for analyzing LPG and propylene concentrates using gas chromatography to determine their composition.
3	IS 1448 (Part 119):1985	Methods of Test for Petroleum And Its Products (P : 119) Aromatic Traces In Light Saturated Hydrocarbons By Gas Chromatography	This standard provides the method for detecting and quantifying aromatic traces in light saturated hydrocarbons using gas chromatography.
4	IS 1448 (Part 144):1993	Methods of Test for Petroleum And Its Products [P:144] Non - Condensable Gases In C2 And Lighter Hydrocarbon Products By Gas Chromatography	This standard specifies the procedure for determining non-condensable gases in C2 and lighter hydrocarbon products using gas chromatography.
5	IS 1448 (Part 151): 2004 ISO7941	Methods of Test for Petroleum And Its Products [P: 151] Commercial Propane And Butane - Analysis By Gas Chromatography	This standard outlines the method for analyzing commercial propane and butane using gas chromatography.
6	IS 1448 (Part 163):2018	Methods of Test for Petroleum And Its Products [P : 163] Determination Of Gasoline Diluent In Used Gasoline Engine Oils By Gas Chromatography	This standard provides the method for determining the amount of gasoline diluent in used gasoline engine oils using gas chromatography.
7	IS 1448 (Part 181):2020 ISO 22854:2018	Methods of Test for Petroleum And Its Products Part 181 Liquid Petroleum Products- Determination Of Hydrocarbon Types And Oxygenates In Automotive Motor Gasoline And In Ethanol (E85)	This standard specifies the method for determining hydrocarbon types and oxygenates in automotive motor gasoline and ethanol (E85) fuel using multidimensional gas chromatography.

S. No	IS No.	IS Title	Scope/Brief Description
		Automotive Fuel - Multidimensional Gas Chromatography Method	
8	IS/ISO 14718: 1998	Animal Feeding Stuffs - Determination Of Aflatoxin B1 Content Of Mixed Feeding Stuffs - Method Using High-Performance Liquid Chromatography	This standard outlines the method for determining the aflatoxin B1 content in mixed animal feeding stuffs using high-performance liquid chromatography (HPLC).
9	IS 15120: 2002 ISO14565	Animal Feeding Stuffs - Determination Of Vitamin A Content- Method Using High Performance Liquid Chromatography	This standard specifies the procedure for determining the vitamin A content in animal feeding stuffs using high-performance liquid chromatography (HPLC).
10	IS 15695: 2006 ISO11027	Pepper And Pepper Oleoresins - Determination Of Piperine Content- Method Using High-Performance Liquid Chromatography	This standard provides the method for determining the piperine content in pepper and pepper oleoresins using high-performance liquid chromatography (HPLC).
11	IS 15697 (Part 2) :2006ISO 7543-2	Chillies And Chilli Oleoresins - Determination Of Total Capsaicinoid Content: Part 2 Method Using High - Performance Liquid Chromatography	This standard outlines the method for determining the total capsaicinoid content in chillies and chilli oleoresins using high-performance liquid chromatography (HPLC).
12	IS 15937: 2011	Meat And Meat Products - Determination Of Chloramphenicol Content - Method Using Liquid Chromatography	This standard specifies the method for determining the chloramphenicol content in meat and meat products using liquid chromatography.
13	IS 15938: 2011 ISO13496: 2000	Meat And Meat Products - Detection Of Colouring Agents - Method Using Thin - Layer Chromatography	This standard provides the procedure for detecting colouring agents in meat and meat products using thin-layer chromatography.
14	IS 15948: 2011 ISO6867:2000	Animal Feeding Stuffs - Determination Of Vitamin E Content- Method Using High-Performance Liquid Chromatography	This standard outlines the method for determining the vitamin E content in animal feeding stuffs using high-performance liquid chromatography (HPLC).

S. No	IS No.	IS Title	Scope/Brief Description
15	IS 15952: 2012 ISO14797: 1999	Animal Feeding Stuffs - Determination of Furazolidone Content - Method Using High-Performance Liquid Chromatography	This standard specifies the method for determining the furazolidone content in animal feeding stuffs using high-performance liquid chromatography (HPLC).
16	IS 16027: 2012 ISO10727: 2002	Tea And Instant Tea In Solid Form - Determination Of Caffeine Content- Method Using High - Performance Liquid Chromatography	This standard provides the procedure for determining the caffeine content in tea and instant tea in solid form using high- performance liquid chromatography (HPLC).
17	IS 16028: 2012 ISO20481: 2008	Coffee And Coffee Products - Determination of the Caffeine Content Using High Performance Liquid Chromatography (Hplc) - Reference Method	This standard outlines the method for determining the caffeine content in coffee and coffee products using high-performance liquid chromatography (HPLC).
18	IS 16031: 2012 ISO11292: 1995	Instant Coffee-Determination of Free and Total Carbohydrate Contents - Method Using High - Performance Anion - Exchange Chromatography	This standard specifies the method for determining the free and total carbohydrate contents in instant coffee using high-performance anion-exchange chromatography.
19	IS 16082: 2013 IEC61619: 1997	Insulating Liquids - Contamination By Polychlorinated Biphenyls (Pcbs)- Method Of Determination By Capillary Column Gas Chromatography	This standard provides the method for determining contamination by polychlorinated biphenyls (PCBs) in insulating liquids using capillary column gas chromatography.
20	IS 16139 (Part 1) :2014 ISO 17734-1:2006	Workplace Air - Determination Of Organonitrogen Compounds In Air Using Liquid Chromatography And Mass Spectrometry: Part 1 Isocyanates Using Dibutylamine Derivatives	This standard outlines the method for determining isocyanates in workplace air using liquid chromatography and mass spectrometry, specifically using dibutylamine derivatives.
21	IS 16139 (Part 2) : 2014 ISO 17734-2:2006	Workplace Air-Determination of Organonitrogen Compounds In Air Using Liquid Chromatography And Mass Spectrometry: Part 2 Amines	This standard specifies the method for determining amines and aminoisocyanates in workplace air using liquid chromatography and mass

S. No	IS No.	IS Title	Scope/Brief Description
		And Aminoisocyanates Using Dibutylamine And Ethy l Chloroformate Derivatives	spectrometry, using dibutylamine and ethyl chloroformate derivatives.
22	IS 16197 (Part 6):2018 IEC 62321-6:2015	Determination Of Certain Substances In Electrotechnical Products Part 6 Polybrominated Biphenyls And Polybrominated Diphenyl Ethers In Polymers By Gas Chromatography Mass Spectrometry (Gc-Ms)	This standard provides the method for determining polybrominated biphenyls and polybrominated diphenyl ethers in polymers used in electrotechnical products using gas chromatography-mass spectrometry (GC-MS).
23	IS 16197 (Part 8) : 2020 IEC 62321-8:2007	Determination Of Certain Substances In Electrotechnical Products Part 8 Phthalates In Polymers By Gas Chromatography - Mass Spectrometry (Gc-Ms), Gas Chromatography - Mass Spectrometry Using A Pyrolyzer / Thermal Desorption Accessory (Py- Td-Gc-Ms)	This standard outlines the method for determining phthalates in polymers used in electrotechnical products using gas chromatography-mass spectrometry (GC-MS) and GC-MS with a pyrolyzer/thermal desorption accessory (Py-TD-GC- MS).
24	IS 16297(Part 1) : 2014 ISO 17226-1:2008	Leather- Chemical Determination of Formaldehyde Content: Part 1 Method Using HighPerformance Liquid Chromatography	This standard specifies the method for determining the formaldehyde content in leather using high-performance liquid chromatography (HPLC).
25	IS 16357: 2017 ISO13685: 1997	Ginger And Its Oleoresins - Determination Of The Main Pungent Components (Gingerols And Shogaols) - Method Using High-Performance Liquid Chromatography	This standard specifies a method for determining the main pungent components, gingerols, and shogaols, in ginger and its oleoresins using high-performance liquid chromatography (HPLC).
26	IS 16552: 2017	Textile Auxiliaries-Chemical Determination of Formaldehyde Content - Method Using High Performance Liquid Chromatography	This standard outlines the method for determining the formaldehyde content in textile auxiliaries using high-performance liquid chromatography (HPLC).
27	IS 16639: 2018 ISO20633: 2015	Infant Formula And Adult Nutritionals - Determination Of Vitamin E And Vitamin A	This standard specifies a method for determining the content of vitamins E and A in

S. No	IS No.	IS Title	Scope/Brief Description
		By Normal Phase High Performance Liquid Chromatography	infant formula and adult nutritionals using normal phase high-performance liquid chromatography (HPLC).
28	IS 16640: 2018 ISO20634: 2015	Infant Formula And Adult Nutritionals - Determination Of Vitamin B12 By Reversed Phase High Performance Liquid Chromatography (Rp - Hplc)	This standard specifies a method for determining vitamin B12 in infant formula and adult nutritionals using reversed phase high-performance liquid chromatography (RP-HPLC).
29	IS 16641: 2018 ISO20638: 2015	Infant Formula-Determination Of Nucleotides By Liquid Chromatography	This standard outlines the method for determining nucleotides in infant formula using liquid chromatography.
30	IS 16642: 2018 ISO20639: 2015	Infant Formula And Adult Nutritionals - Determination Of Pantothenic Acid By Ultra High Performance Liquid Chromatography And Tandem Mass Spectrometry Method (Uhplc - Ms/Ms)	This standard specifies the method for determining pantothenic acid in infant formula and adult nutritionals using ultra high-performance liquid chromatography and tandem mass spectrometry (UHPLC-MS/MS).
31	IS 16649: 2018 ISO20637: 2015	Infant Formula And Adult Nutritionals-Determination Of Myo- Inositol By Liquid Chromatography And Pulsed Amperometry	This standard outlines the method for determining myo-inositol in infant formula and adult nutritionals using liquid chromatography and pulsed amperometry.
32	IS 16658: 2018	Tobacco and Tobacco Products - Cigarette Filters - Determination Of Nicotine Alkaloid Retention Index And Water Retention Index By Gas Chromatography - Direct Method	This standard specifies the method for determining the nicotine alkaloid retention index and water retention index of cigarette filters using gas chromatography.
33	IS 17176: 2019 ISO20635: 2018	Infant Formula And Adult Nutritionals "Determination Of Vitamin C By (Ultra) High Performance Liquid Chromatography With Ultraviolet Detection ((U) Hplc-Uv)"	This standard specifies a method for determining vitamin C in infant formula and adult nutritionals using (ultra) high-performance liquid chromatography with ultraviolet detection ((U)HPLC-UV).

S. No	IS No.	IS Title	Scope/Brief Description
34	IS 17177: 2019 ISO20636: 2018	Infant Formula And Adult Nutritionals - Determination Of Vitamin D By Liquid Chromatography - Mass Spectrometry	This standard outlines the method for determining vitamin D in infant formula and adult nutritionals using liquid chromatography-mass spectrometry.
35	IS 17460: 2021 ISO18395: 2005	Animal And Vegetable Fats And Oils- Determination Of Monoacylglycerols, Diacylglycerols, Triacylglycerols And Glycerol By High-Performance Size-Exclusion Chromatography (Hpsec) (Adoption Of ISO 18395 : 2005)	This standard specifies the method for determining monoacylglycerols, diacylglycerols, triacylglycerols, and glycerol in animal and vegetable fats and oils using high-performance size-exclusion chromatography (HPSEC).
36	IS 17562: 2021 ISO22855: 2008	Fruit And Vegetable Products - Determination Of Benzoic Acid And Sorbic Acid Concentrations - High Performance Liquid Chromatography Method	This standard specifies the method for determining benzoic acid and sorbic acid concentrations in fruit and vegetable products using high-performance liquid chromatography.
37	IS 17668: 2021 ISO21468: 2020	Infant Formula And Adult Nutritionals Determination of Free And Total Choline And Free And Total Carnitine Liquid Chromatography Tandem Mass Spectrometry Hplc-Msms	This standard outlines the method for determining free and total choline and free and total carnitine in infant formula and adult nutritionals using liquid chromatography tandem mass spectrometry (HPLC-MS/MS).
38	IS 17670: 2021 ISO23305: 2020	Fortified Milk Powders Infant Formula And Adult Nutritionals Determination Of Total Biotin By Liquid Chromatography Coupled With Immunoaffinity Column Clean-Up Extraction	This standard specifies the method for determining total biotin in fortified milk powders, infant formula, and adult nutritionals using liquid chromatography coupled with immunoaffinity column clean-up extraction.
39	IS 17671: 2021 ISO23443: 2020	Infant Formula And Adult Nutritionals Determination Of Beta- Carotene Lycopene And Lutein By Reversed-Phase Ultra-High Performance Liquid Chromatography Rp-Uhplc	Outlines the method for determining beta-carotene, lycopene, and lutein in infant formula and adult nutritionals using RP-UHPLC.

S. No	IS No.	IS Title	Scope/Brief Description
40	IS 17804 (Part 2) :2022 ISO 14502-2:2005	Determination Of Substances Characteristic Of Green And Black Tea Part 2: Content Of Method Using High-Performance Liquid Chromatography (Adoption Of ISO 14502-2 : 2005 Along With Its Cor 1 :2006)	Specifies the method for determining the content of Catechins in Green Tea-catechins in green tea using HPLC.
41	IS 17808 (Part 1) :2022ISO 22744-1:2020	Textiles And Textile Products Determination Of Organotin Compounds Part 1: Derivatization Method Using Gas Chromatography	Specifies the method for determining organotin compounds in textiles and textile products using the derivatization method with gas chromatography.
42	IS 17808 (Part 2):2022 ISO 22744-2:2020	Textiles And Textile Products Determination Of Organotin Compounds Part 2: Direct Method Using Liquid Chromatography	Outlines the method for determining organotin compounds in textiles and textile products using the direct method with liquid chromatography.
43	IS 17950 (Part 1):022 ISO 16014-1:2019	Plastics Determination Of Average Molecular Weight and Molecular Weight Distribution Of Polymers Using Size-Exclusion Chromatography Part 1 General Principles	Specifies the general principles for determining the average molecular weight and molecular weight distribution of polymers using size- exclusion chromatography.
44	IS 17950 (Part 2):022 ISO 16014-2:2019	Plastics Determination Of Average Molecular Weight and Molecular Weight Distribution Of Polymers Using Size-Exclusion Chromatography Part 2 Universal Calibration Method	Outlines the universal calibration method for determining the average molecular weight and molecular weight distribution of polymers using size-exclusion chromatography.
45	IS 17950 (Part 3): 2022 ISO 16014-3:2019	Plastics Determination Of Average Molecular Weight and Molecular Weight Distribution Of Polymers Using Size-Exclusion Chromatography Part 3 Low- Temperature Method	Specifies the low-temperature method for determining the average molecular weight and molecular weight distribution of polymers using size-exclusion chromatography.
46	IS 17950 (Part 4): 2022 ISO 16014-4:2019	Plastics Determination Of Average Molecular Weight And Molecular Weight Distribution	Outlines the high-temperature method for determining the average molecular weight and

S. No	IS No.	IS Title	Scope/Brief Description
		Of Polymers Using Size-Exclusion Chromatography Part 4 High- Temperature Method	molecular weight distribution of polymers using size-exclusion chromatography.
47	IS 17950 (Part 5):2022 ISO 16014-5:2019	Plastics Determination Of Average Molecular Weight and Molecular Weight Distribution Of Polymers Using Size-Exclusion Chromatography Part 5 Light- Scattering Method	Specifies the light-scattering method for determining the average molecular weight and molecular weight distribution of polymers using size-exclusion chromatography.
48	IS 18108: 2023 ISO14674: 2005	Milk And Milk Powder "Determination Of Aflatoxin M1 Content Clean-Up By Immunoaffinity Chromatography And Determination By Thin-Layer Chromatography (Adoption Of ISO 14674: 2005)	Specifies the method for determining aflatoxin M1 content in milk and milk powder using clean- up by immunoaffinity chromatography and determination by thin-layer chromatography.
49	IS 18110: 2023 ISO14501:2021	Milk And Milk Powder - Determination Of Aflatoxin M1 Content - Clean-Up By Immunoaffinity Chromatography And Determination By High-Performance Liquid Chromatography (Adoption Of ISO 14501:2021)	Specifies the method for determining aflatoxin M1 content in milk and milk powder using clean- up by immunoaffinity chromatography and determination by HPLC.
50	IS 18144: 2023 ISO17372: 2008	Animal Feeding Stuffs "Determination of Zearalenone By Immunoaffinity Column Chromatography And High Performance Liquid Chromatography"	Outlines the method for determining zearalenone in animal feeding stuffs using immunoaffinity column chromatography and HPLC.
51	IS 18452: 2023 22818:2021	Textiles Determination Of Short- Chain Chlorinated Paraffins Sccp And Middle-Chain Chlorinated Paraffins Mccp In Textile Products Out Of Different Matrices By Use Of Gas Chromatography Negative Ion Chemical Ionization Mass Spectrometry Gc-Nci-Ms	Specifies the method for determining SCCP and MCCP in textile products using GC-NCI-MS.

S. No	IS No.	IS Title	Scope/Brief Description
52	IS 18528: 2023 ISO14939: 2001	Animal Feeding Stuffs - Determination Of Carbadox Content- Method Using High-Performance Liquid Chromatography	Outlines the method for determining carbadox content in animal feeding stuffs using HPLC.
53	IS 18621: 2024 ISO21160:2018	Cigarettes- Determination of Selected Carbonyls In The Mainstream Smoke Of Cigarettes Method Using High Performance Liquid Chromatography	Specifies the method for determining selected carbonyls in the mainstream smoke of cigarettes using HPLC.
54	IS 18628: 2024 ISO23919: 2020	Cigarettes- Determination Of Ammonia In Cigarette Mainstream Smoke Using Ion Chromatography	Outlines the method for determining ammonia in cigarette mainstream smoke using ion chromatography.
55	IS 19005: 2023	Method of Test-Determination Of Ochratoxin A In Wine By High Performance Liquid Chromatography With Immunoaffinity Column And Fluorescence Detection	Specifies the method for determining ochratoxin A in wine using HPLC with immunoaffinity column and fluorescence detection.
56	IS 3025 (Part 60):2023	Methods of Sampling and Test Physical And Chemical For Water And Wastewater Part 60 Fluoride Section 1 Ion-Selective Electrode Spands And LiquidChromatography Methods Second Revision	Outlines methods for determining fluoride in water and wastewater using ion-selective electrode spands and liquid chromatography.
57	IS 3025 (Part 67):2018 ISO 15061: 2001	Methods of Sampling and Test (Physical And Chemical) For Water And Wastewater: Part 67 Determination of Dissolved Bromate- Method By Liquid Chromatography Of Ions	Specifies the method for determining dissolved bromate in water and wastewater using liquid chromatography of ions.
58	IS 3025 (Part 71):2021ISO 14911: 1998	Methods of Sampling and Test Physical And Chemical For Water And Wastewater Part 71 Determination Of Dissolved Cations Using Ion Chromatography	Outlines the method for determining dissolved cations in water and wastewater using ion chromatography.
59	IS 3025 (Part 75):2022 ISO 10304-1:2007	Methods of Sampling and Test Physical And Chemical For Water And Waste water Part	Specifies the method for determining dissolved anions in water and wastewater using

S. No	IS No.	IS Title	Scope/Brief Description
		75 Determination Of Dissolved Anions By Liquid Chromatography of Ions	liquid chromatography of ions.
60	IS 5182 (Part 17):1979	Methods For Measurement of Air Pollution: Part 17 C1 To C2 Hydrocarbons In Air By Gas Chromatography	Outlines the method for measuring C1 to C2 hydrocarbons in air using gas chromatography.
61	IS 5182 (Part 21):2001	Methods For Measurement of Air Pollution: Part 21 Non Methane Hydrocarbons In Air By Gas Chromatography	Specifies the method for measuring non-methane hydrocarbons in air using gas chromatography.
62	IS 548 (Part 3/ Sec 3): 2021 ISO/TS17383: 2014	Methods of Sampling and Test for Oils and Fats - Part 3 Advanced Instrumental Methods Section 3 Determination Of The Triacylglycerol Composition Of Fats And Oils By Capillary Gas Chromatography (Adoption Of ISO/TS 17383 : 2014)	Specifies the method for determining the triacylglycerol composition of fats and oils using capillary gas chromatography.
63	IS 548 (Part 3/ Sec 5): 2021ISO/ TS23647: 2010	Methods of Sampling and Test For Oils And Fats Part 3 Advanced Instrumental Methods Section 5 Determination Of Wax Content by Gas Chromatography (Adoption of ISO/TS 23647 : 2010)	Outlines the method for determining the wax content in oils and fats using gas chromatography.
64	IS 582 (Part 8): 201813365: 2011	Methods of Chemical Testing of Leather Part 8 Determination of the Preservative (TCMTB, PCMC, OPP, OIT) Content In Leather By Liquid Chromatography	Specifies the method for determining the preservative content (TCMTB, PCMC, OPP, OIT) in leather using liquid chromatography.

Annex-V

Test Methods based on Titrations Techniques

S. No	IS No.	IS Title	Scope/Brief Description
1	IS 3025 Part 26:2021	Determination of Chlorine Residual in Packaged Drinking Water	This standard specifies a method for the determination of residual chlorine in packaged drinking water using a colorimetric method.
2	Annex-D of IS 7224: 2006	Determination of Chloride in Iodized Salt, vacuum evaporated iodized saltand refined iodized salt	This annex provides a method for the determination of chloride content in iodized salt, vacuum evaporated iodized salt, and refined iodized salt using the Mohr's method.
3	Annex- F of IS 7224: 2006	Determination of Calcium & Magnesium in Iodized Salt, vacuum evaporatediodized salt and refined iodized salt	This annex outlines a method for the determination of calcium and magnesium in iodized salt, vacuum evaporated iodized salt, and refined iodized salt using EDTA titrimetry.
4	Annex- H of IS 7224: 2006	Determination of Iodine in Iodized Salt, vacuum evaporated iodized salt and refined iodized salt	This annex specifies a method for the determination of iodine content in iodized salt, vacuum evaporated iodized salt, and refined iodized salt using iodometric titration.
5	Annex - C of IS 251: 2024	Determination of Total Alkalinity in Soda Ash	This annex provides a method for the determination of total alkalinity in soda ash using a titrimetric method with hydrochloric acid.

Annex-VI

Test Methods based on Gravimetric Techniques

S. No	IS No.	IS Title	Scope/Brief Description
1	Annex- B of IS 7224: 2006	Determination of Water Insoluble matter in Iodized Salt, vacuum evaporated iodized salt and refined iodized salt	This annex specifies a method for the determination of water insoluble matter in iodized salt, vacuum evaporated iodized salt, and refined iodized salt using filtration and drying techniques.
2	Annex-6 of IS 252: 2013	Determination of Sulphates in Caustic Soda	This annex provides a method for the determination of sulphate content in caustic soda using a gravimetric method.
3	Annex A of IS 11673 Part 1: 2019	Determination of Relative Density of Sodium Hypochlorite Solution	This annex outlines a method for the determination of the relative density of sodium hypochlorite solution using a hydrometer.
4	IS 3025 (Part24/ Sec 1): 2022	Methods Of Sampling And Test (Physical And Chemical) For Water And Waste Water Part 24 Sulphates Section 1 Gravimetric And Turbidity Methods	This standard (Part 24/Sec 1) specifies the following methods for determination of sulphates in water and wastewater: a) Gravimetric method; and b) Turbidity method.

Annex-VII

Indian Standards on Products where more than One of the above Test Methods are Used

S. No	IS No.	IS Title	Scope/Brief Description
1	IS 6831: 2023	Caustic Potash Specification	Used in the production of potassium carbonate, potassium phosphates, liquid fertilizers, and various potassium chemicals.
2	IS 252: 2013	Caustic Soda - Specification	Essential in pulp and paper manufacturing, textiles, soaps, detergents, water treatment, and chemical synthesis.
3	IS 299: 2012	Alumino -Ferric - Specification	Water treatment, effluent treatment, and wastewater management applications.
4	IS 10115: 1982	Specification For Phosphorus Pentasulphide	Lubricant additives, flotation agents, and pesticide production.
5	IS 10116: 2015	Boric Acid- Specification	Glass production, antiseptics, insecticides, and nuclear power plants.
6	IS 10125: 1982	Specification For Copper Carbonate	Pigments, catalysts, glass coloring, and ceramics.
7	IS 10271: 1982	Specification For Anhydrous Hydrogen Fluoride, Technical	Etching, metal surface treatment, and fluorine compound synthesis.
8	IS 10332: 1982	Specification For Hydrofluoric Acid, Aqueous	Glass etching, chemical polishing, and semiconductor industry applications.
9	IS 1040: 1987	Specification For Calcium Carbide, Technical	Acetylene generation, desulfurization of iron, and steel production.
10	IS 10535: 1983	Specification For Manganese Sulphate, Monohydrate	Fertilizer production, animal nutrition, and ceramic glazes.
11	IS 1078: 1987	Specification For Copper Naphthenate	Wood preservation and antifouling coatings.
12	IS 1089: 1986	Specification For Oleum, Technical	Sulfuric acid manufacturing, explosives, and chemical processes requiring strong acids.

S. No	IS No.	IS Title	Scope/Brief Description
13	IS 10895: 1984	Specification For Copper Nitrate	Ceramic glazes, catalyst manufacturing, and fireworks.
14	IS 10896: 1984	Specification For Aluminium Hydroxide, Technical	Water purification, flame retardants,and ceramic production.
15	IS 10904: 1984	Specification For Sodium Fluoride, Technical	Dental care products, water fluoridation, and pesticide manufacturing.
16	IS 1109: 1980	Specification For Borax	Laundry detergents, ceramic glazes, and pH buffering.
17	IS 11112: 1984	Specification For Alumina, Chromatographic Grade	Analytical chemistry, chromatography columns.
18	IS 1113: 1965	Specification For Ammonium Chloride, Technical and Pure	Fertilizers, pharmaceuticals, and metal cleaning.
19	IS 11153: 1996	Manganese Dioxide For Dry Batteries - Specification	Dry cell battery production.
20	IS 11224: 1985	Specification For Rock Phosphate For Chemical Industries	Fertilizer manufacturing and agricultural applications.
21	IS 11236: 1985	Specification For Manganese Acetate	Catalysts, dye intermediates, and paint drying agents.
22	IS 11237: 1985	Specification For Manganese Carbonate	Fertilizer blends, ceramic glazes, and pigment production.
23	IS 11305: 1985	Specification For Thionyl Chloride	Organic chemistry synthesis, pharmaceutical manufacturing, and chemical synthesis.
24	IS 11657: 2020	Phosphorus Oxychloride Technical Specification First Revision	Agrochemicals, pharmaceuticals, and plasticizer production.
25	IS 11744: 2020	Phosphorous Pentachloride, Technical - Specification	Organic chemistry synthesis and chlorination processes.
26	IS 11782: 2024	Sodium Cyanide, Technical Specification	Gold extraction in mining, chemical manufacturing, and metal plating.
27	IS 12008: 2023	Silica Gel Chromatographic Grade Specification	Analytical chemistry, chromatography columns.
28	IS 12178: 2022	Acetylene Black Specification	Battery manufacturing, rubber compounding, and electronic devices.

S. No	IS No.	IS Title	Scope/Brief Description
29	IS 12292: 1988	Specification For Lead Suboxide (Lead Oxide) For Lead - Acid Storage Battery	Lead-acid battery production.
30	IS 12478: 1988	Specification For Ammonium Sulphate, Technical	Fertilizer blends, flame retardants, and food processing.
31	IS 1290: 2023	Mineral Gypsum Specification	Building materials, plaster production, and cement manufacturing.
32	IS 13057: 1991	Potassium Iodate	Iodized salt production and dietary supplements.
33	IS 1314: 1984	Specification For Calcium Chloride	De-icing roads, dust suppression, and food additives.
34	IS 13425 : 1992	Ammonium Nitrate for Nitrous Oxide Production-Specification	Medical anesthesia, industrial gas production.
35	IS 1420: 1989	Light Basic Magnesium Carbonate - Specification	Pharmaceutical formulations, rubber industry, and cosmetics.
36	IS 14211: 1994	Molecular Sieves - Specification	Gas drying, air separation, and petrochemical industries.
37	IS 14295: 1995	Calcium Fluoride - Specification	Calcium Fluoride is used in metallurgy, aluminum production, glass and ceramics manufacturing, optical components, and as a source of fluoride ions in various chemical processes.
38	IS 14305: 1995	Basic lead Carbonate - Specification	Paints, pigments, and ceramic glazes.
39	IS 14780: 2000	Zinc Naphthenate - Specification	Wood protection and antifouling coatings.
40	IS 14781: 2000	Sodium Thiosulphate - Specification	Photographic processing, medical applications, and water dechlorination.
41	IS 14932: 2001	Sulfamic Acid - Specification	Descaling of boilers and heat exchangers, catalyst in chemical reactions, and pharmaceuticals.
42	IS 1540 (Part 1) :1980	Specification For Quick Lime And Hydrated Lime For Chemical Industries: Part 1 Quick Lime	Steel production, water purification, and soil stabilization.

S. No	IS No.	IS Title	Scope/Brief Description
43	IS 1540 (Part 2):1990	Quicklime And Hydrated Lime For Chemical Industries - Specification: Part 2 Hydrated Lime	Construction materials, paper production, and environmental remediation.
44	IS 1612: 1976	Specification For Iron Powder (Reduction Grade)	Metallurgical processes, chemical synthesis, and magnetic materials.
45	IS 1919: 1982	Specification For Sodium Hydrosulphite	Textile dyeing, pulp and paper bleaching, and wastewater treatment.
46	IS 2080: 2021	Specification For Stabilized Hydrogen Peroxide	Textile bleaching, disinfectants, and chemical processes.
47	IS 2124: 2000	Sodium Bicarbonate - Specification	Baking soda, pharmaceutical preparations, and alkalinity adjustment in water.
48	IS 2124: 2023	Sodium Bicarbonate Specification	Food additives, medicinal applications, and personal hygiene products.
49	IS 2142: 2023	Bromine Technical Specification	Flame retardants, pharmaceutical synthesis, and agriculture.
50	IS 2449: 2023	Silver Oxide Specification	Battery electrodes, conductive ink, and chemical catalysts.
51	IS 247: 2023	Sodium Sulphite, Anhydrous Specification	Photographic developers, textile bleaching, and water dechlorination.
52	IS 248: 2023	Sodium Bisulphite Technical Sodium Metabisulphite Specification	Water dechlorination, food preservation, and chemical reduction reactions.
53	IS 249: 2022	Sodium Bichromate Technical Specification	Metal finishing, corrosion protection, and pigment production.
54	IS 250: 2022	Potassium Bichromate Technical And Analytical Reagent - Specification	Analytical chemistry standards, leather tanning, and photographic emulsions.
55	IS 251: 1998	Soda ash, Technical-Specification	De-icing roads, dust suppression, and dietary supplements.
56	IS 254: 2023	Magnesium Chloride Specification	Detergent manufacturing, textile dyeing, and paper production.

S. No	IS No.	IS Title	Scope/Brief Description
57	IS 255: 2023	Sodium Sulphate Anhydrous Technical Grade Specification	Detergent additives, textile industry, and chemical reactions.
58	IS 256: 2024	Glauber Salt (Sodium Sulphate, Decahydrate), Technical Specification	Water treatment, cosmetics manufacturing, and food additives.
59	IS 258: 2000	Potash Alum- Specification	Water purification, leather industry, and food preservation.
60	IS 259: 1969	Specification For Ammonium Alum	Water treatment plants, paper mills, and textile dyeing.
61	IS 260: 2001	Aluminium Sulphate, Non - Ferric - Specification	Water treatment plants, paper mills, and textile dyeing.
62	IS 261: 2023	Copper Sulphate Specification	Agriculture (as a fertilizer and fungicide), and metal plating.
63	IS 262: 2022	Ferrous Sulphate Heptahydrate Specification	Agricultural fertilizers, water purification, and animal feed additives.
64	IS 264: 2005	Nitric Acid- Specification	Explosives manufacturing, fertilizer production, and metal etching.
65	IS 265: 2021	Hydrochloric Acid Specification	Metal surface treatment, food additives, and industrial cleaning agents.
66	IS 266: 1993	Sulphuric Acid - Specification	Fertilizer production, detergent formulation, and chemical manufacturing.
67	IS 2723: 1985	Specification For Ammonium	Bromide, Pure And Analytical Reagent Photographic developers, pharmaceutical synthesis, and analytical standards.
68	IS 2730: 1977	Specification For Magnesium Sulphate (Epsom Salts)	Agricultural fertilizers, medical treatments, and cosmetic formulations.
69	IS 2752: 1995	Activated Carbons, Granular- Specification	Water treatment systems, air filters, and solvent purification.
70	IS 2780: 1964	Specification For Sodium Bromide, Pure	Pharmaceutical preparations, photographic emulsions, and oil well drilling.

S. No	IS No.	IS Title	Scope/Brief Description
71	IS 2797: 1998	Potassium Bromide - Specification	Photographic developers, pharmaceutical formulations, and analytical standards.
72	IS 2881: 1984	Specification For Barytes For Chemical Industry And Oil - Well Drilling	Oil well drilling muds, pigment manufacturing, and chemical processing.
73	IS 296 : 2023	Sodium Carbonate Anhydrous Specification	Glass production, detergent formulation, and chemical synthesis.
74	IS 297 : 2001	Sodium Sulphide, Technical - Specification	Used in leather processing, water treatment, and as a reducing agent in various chemical reactions.
75	IS 3204 : 1978	Specification For Limestone For Chemical Industry	Used as a raw material in the production of lime, cement, and in the desulfurization of flue gases.
76	IS 3205 : 1984	Specification For Precipitated Barium Carbonate, Technical	There shall be two grades of the material, namely : Grade 1 for use in electro-ceramic. Grade 2 for use in the manufacture of barium salts.
77	IS 333 : 2023	Potassium Permanganate Specification	Used as an oxidizing agent in water treatment, disinfectants, and in organic synthesis.
78	IS 3401 : 2023	Silica Gel Specification	Used as a desiccant for drying gases and liquids, in chromatography, and as a catalyst support.
79	IS 3598 : 1983	Specification For Sodium Perborate, Tetrahydrate	Used as a bleaching agent in detergents and cleaning products, and in tooth whitening formulations.
80	IS 3605 : 1984	Specification For Bauxite For Chemicals And Petroleum Industries	Used in the production of alumina, aluminum, and as a catalyst in petroleum refining.
81	IS 3607 : 1979	Specification For Magnesite ForChemical Industry	Used in the production of magnesium compounds, refractory materials, and as a filler in rubber and plastics.

S. No	IS No.	IS Title	Scope/Brief Description
82	IS 376: 2023	Sodium Hydroxide Analytical Reagent Specification	Used in laboratories for titrations, pH adjustments, and in chemical synthesis.
83	IS 380: 2023	French Chalk Technical Specification	Used as a lubricant, in cosmetics, and as a marking tool in metalworking.
84	IS 381: 2024	Sodium Silicate Specification	Used in detergents, water treatment, and as a binder in the manufacture of refractory materials.
85	IS 4150: 1984	Specification For Potassium Chloride, Technical	There shall be two grades of the material, namely: a) Grade 1 - for use in the manufacture of caustic potash by electrolysis. b) Grade 2 - for use in chemical industry in general for the manufacture of potassiumsalts. Used in fertilizers, pharmaceuticals, and as a laboratory reagent.
86	IS 4200: 2020	Sodium Aluminate - Specification	Used in water treatment, as a coagulant, and in the production of alumina-based chemicals.
87	IS 4256: 2021	Hydrated Calcium Sulphate From Marine Brine - Specification	Used in construction materials, as a soil conditioner, and in the production of plaster.
88	IS 4408: 1979	Specification For Sodium Chloride,Analytical Reagent	Used in laboratories for analytical purposes, in pharmaceuticals, and in the preparation of saline solutions.
89	IS 4505: 2015	Sodium Formaldehyde Sulphoxylate- Specification	Used as a reducing agent in dyeing, printing textiles, and in the manufacture of rubber.
90	IS 4581: 2021	Phosphorus Trichloride Pure And Analytical Reagent-Specification	Used in the production of organophosphorus compounds, as a reagent in laboratories, and in pesticide manufacturing.
91	IS 4611: 1991	Metallic Zinc Powder (Zinc Dust) -Specification	Used in anti-corrosion coatings, as a reducing agent, and in the manufacture of batteries.
92	IS 4737: 1982	Specification For Chromite For Chemical Industries	Used in the production of chromium chemicals, in

S. No	IS No.	IS Title	Scope/Brief Description
			refractories, and in the manufacture of ferrochromium alloys.
93	IS 494: 2024	Aluminium Stearate For Lubricants Specification	Used as a thickening agent in greases, in cosmetics, and as a waterproofing agent in construction materials.
94	IS 505: 2024	Light Kaolin Specification	Used in ceramics, paper manufacturing, and as a filler in paints and rubber products.
95	IS 5288: 1980	Barium Chloride	Used in the manufacture of pigments, in the purification of brine solution in caustic chlorine plants, and in fireworks.
96	IS 5301: 1987	Sodium Chlorate	Used as a herbicide, in the manufacture of chlorine dioxide, and as an oxidizing agent.
97	IS 5316: 1998	Ammonium Carbonate - Specification	Used in baking powders, pharmaceuticals, and as a leavening agent.
98	IS 5321: 2022	Specification For Soda Lime As Carbon Dioxide Absorbent	Used in anesthesia, oxygen therapy, and in rebreathers.
99	IS 566: 2024	Disodium Phosphate, Dodecahydrate Â•” Specification	Used in water treatment, detergents, and food additives.
100	IS 567: 2024	Disodium Phosphate, AnhydrousÂ•” Specification	Used in water treatment, detergents, and food additives.
101	IS 571: 2000	Monosodium Phosphate Specification	Used in water treatment, as a buffering agent, and in food additives.
102	IS 573: 2023	Trisodium Phosphate Specification	Used in cleaning agents, water treatment, and as a degreaser.
103	IS 5877: 1971	Specification For Barium Sulphide, Technical (Black Ash)	Used in the production of barium salts, luminous paints, and depilatories.
104	IS 593: 1978	Specification For Salt For Hide Curing (Wet - Salting)	Used in the leather industry for preserving hides and skins.
105	IS 6015: 1984	Specification For Barium Hydroxide	Used in the manufacture of barium salts, lubricating oil

S. No	IS No.	IS Title	Scope/Brief Description
			additives, and in the sugar industry.
106	IS 6100: 2021	Specification For Sodium Tripolyphosphate Anhydrous Technical	Used in detergents, water treatment, and as a food preservative.
107	IS 6135: 1981	Specification For Soda Ash, Fused, Technical	Used in glass manufacturing, water treatment, and as a cleaning agent.
108	IS 6186: 1986	Specification For Bentonite	Used in drilling mud, foundry sand binders, and as a clarifying agent.
109	IS 646: 2020	Liquid Chlorine, Technical Specification	Used in water disinfection, chemical manufacturing, and as a bleaching agent.
110	IS 6507: 1991	Sodium Chromate, Tetrahydrate Specification	Used in metal finishing, leather tanning, and as a corrosion inhibitor.
111	IS 6605: 2023	Potassium Chromate Specification	Used in analytical chemistry, as a mordant in dyeing, and in corrosion control.
112	IS 6614: 2021	Specification For Aluminium Chloride Anhydrous Technical	Used in the production of aluminum, as a catalyst, and in the chemical industry.
113	IS 662: 2020	Anhydrous Ammonia	Used as a fertilizer, refrigerant, and in the manufacture of chemicals.
114	IS 6980: 1983	Specification For Tetrasodium Pyrophosphate, Anhydrous, Technical	Used in detergents, water treatment, and as a dispersing agent.
115	IS 701: 1966	Specification For Zinc Chloride	Used in galvanizing, as a flux in soldering, and in textile processing.
116	IS 711: 2023	Ferric Chloride Technical Specification	Used in water treatment, as a coagulant, and in the production of iron compounds.
117	IS 7129 : 2021	Potassium Carbonate Anhydrous Specification	Used in glass manufacturing, soaps, and as a buffering agent.
118	IS 7163 : 1989	Potassium Iodide, Pure And Analytical Reagent - Specification	Used in pharmaceuticals, photography, and as a nutritional supplement.

S. No	IS No.	IS Title	Scope/Brief Description
119	IS 7223 : 1986	Specification For Potassium Chloride, Analytical Reagent	Used in laboratory analysis, pharmaceuticals, and as a fertilizer.
120	IS 7541: 2023	Stabilized Liquid Sulphur Trioxide Specification	Used in chemical synthesis, sulfonation processes, and in the production of detergents.
121	IS 797 : 2023	Common Salt For Chemical Industries Specification	Used in chemical manufacturing, water treatment, and food processing.
122	IS 798 : 2020	Orthophosphoric Acid — Specification	Specifies requirements for orthophosphoric acid for industrial use.
123	IS 799 : 2023	Ammonia Liquor Specification	Specifies requirements for ammonia liquor for industrial use.
124	IS 8325 : 1983	Specification For Nickel Formate For Nickel Catalyst	Used as a catalyst in hydrogenation reactions and in electroplating.
125	IS 8366 : 1989	Activated Carbons, Powdered - Specification	Used in water treatment, air purification, and as a decolorizing agent.
126	IS 8587 : 1993	Acid Grade Fluorspar For Chemical Industry - Specification	Used in the production of hydrofluoric acid, aluminum, and as a flux in steelmaking.
127	IS 8770 : 1978	Specification For Artificial Sea Water For Laboratory Use	Used in marine biology research and aquarium maintenance.
128	IS 879 : 1981	Specification For Sodium Nitrite	Used in food preservation, dye manufacturing, and as a corrosion inhibitor.
129	IS 8813 : 1995	Potassium Silicate,Technical Specification	Used in welding rods, soaps, and as a cement additive.
130	IS 8814: 1978	Specification For Sodium Metal	Used in chemical synthesis, as a reducing agent, and in the production of sodium compounds.
131	IS 9398 : 1987	Specification For Silicon Tetrachloride, Technical	Used in the production of high-purity silicon, optical fibers, and as a laboratory reagent.
132	IS 9424 : 1979	Specification For Sodium Metastlicate	Used in detergents, water treatment, and as a corrosion inhibitor.

S. No	IS No.	IS Title	Scope/Brief Description
133	IS 9700 : 1991	Activated Alumina - Specification	Used in water purification, as a catalyst support, and in chromatography.
134	IS 9825 : 2003	Chlorine Tablets - Specification	Used in water purification, sanitation, and as a bleaching agent.
135	IS 574 : 1989	Glassy Sodium Metaphosphate Specification	Used in water treatment, detergents, and as a sequestrant.
136	IS 11673 (Part 1) : 2019	Sodium Hypochlorite Solution - Specification: Part 1 Household And Industrial Use	Used as a disinfectant, bleach, and in water treatment.
137	IS 11673 (Part 2) : 2019	Sodium Hypochlorite Solution - Specification: Part 2 Water Treatment Use	Used in water disinfection andsanitation.
138	IS 17439 : 2020	Polyphosphoric Acid - Specification	Used in the production of specialty chemicals, catalysts, and as a dehydrating agent.
139	IS 17440 : 2020	Carbon Black - Specification	Used in rubber manufacturing, as a pigment, and in plastics.
140	IS 17441: 2020	Calcined Alumina - Specification	Used in refractory materials, ceramics, and as a raw material for aluminum production.
141	IS 17443: 2020	Tabular Alumina - Specification	Used in refractory applications, high-temperature ceramics, and abrasives.
142	IS 17444: 2020	Cobalt Acetate - Specification	Used as a catalyst in polyester production, in electroplating, and as a drier in paints.
143	IS 17539: 2021	Silver Catalyst - Specification	Used in catalytic converters, chemical synthesis, and in the production of formaldehyde.
144	IS 17441 (Part 1): 2021	Calcined Alumina - Specification Is 17441 Part 1 Non-Metallurgical Grade	Used in ceramics, refractories, and as an abrasive.

CHAPTER VII
BIBLIOGRAPHY

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BIBLIOGRAPHY

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“All the world is a laboratory to the inquiring mind"