Forensic Chemistry Laboratory

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Forensic

- The word *forensic* comes from the Latin adjective *forensis*, meaning "of or before the forum." In Roman times, a criminal charge meant presenting the case before a group of public individuals in the forum.
- The term "forensic" is effectively a synonym for "legal" or "related to courts".

Forensic Laboratory

Forensic Laboratory

In Some classification the laboratory was divided into

four main areas of investigation:

- Biology
- Chemistry
- DNA
- Drugs / Toxicology

Forensic Laboratory

Forensic Laboratory

Other classification, The laboratory is divided into many areas of investigation:

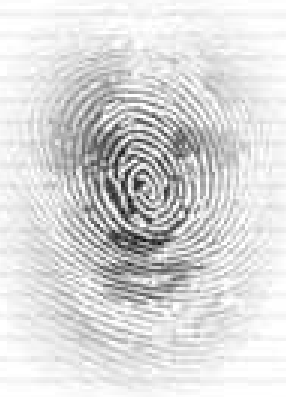
1. Fingerprint lab.
2. Trace evidence lab.
3. Serology / DNA labs.
4. Materials lab.
5. Firearms lab.
6. Photography lab.
7. Chemistry lab.
8. Others labs.

Forensic Laboratory

1. Fingerprint Laboratory

The items to be tested for fingerprints,

- A newspaper,
- A glass bottle,
- A floppy disk, and
- A glossy magazine.



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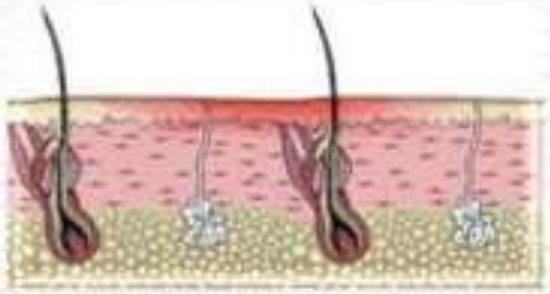
Skin of finger

Skin is generally divided in to two layers.

These are the inner layer (dermis) and the outer layer (epidermis).

The outer layer is divided into five stratified sub-layers, which are listed from bottom to top as,

1. Basal generating layer
2. Spinous layer
3. Granular layer
4. Transitional hyaline layer
5. Horny cornified layer.



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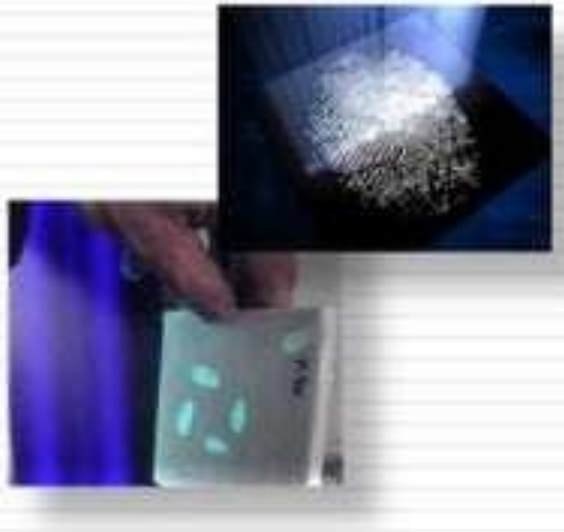
Fingerprint detection techniques

Fingerprint Detection Techniques:

1. Iodine Fuming
2. Superglue Fuming
3. Powders
4. Ninhydrin Spraying



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Fingerprint detection techniques

Some technique's

- A dedicated workstation for the recording and enhancement of latent fingerprints
- An optical projector for the visual comparison of record and recovered fingerprints

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2. Trace Evidence Laboratory

In most labs, a unit commonly known as a 'trace evidence unit' forms an area where scientists look for clues in evidence such as

- Hair,
- Fabric,
- Dust,
- Fiber and
- Skeletal remains.

Refer to the "Every Criminal Leaves A Trace".

Forensic Laboratory

2. Trace Evidence Lab Applications

- Recovering, comparing and identifying non-biological trace evidence
  - Paint,
  - Potential fire accelerants,
  - Glass, fibers and textiles,
  - Plastics, building products,
  - Safe insulation and commercial products;
- Conducting physical matching of the seized materials;
- Providing scientific and technical support to other forensic disciplines; and hosting and supporting the Paint Data Query (PDQ) database.

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Trace Evidence Techniques

Some technique's

- Multi-functional forensic trace evidence analysis system

- Trace evidence elemental analysis by laser induced breakdown spectroscopy - LIBS

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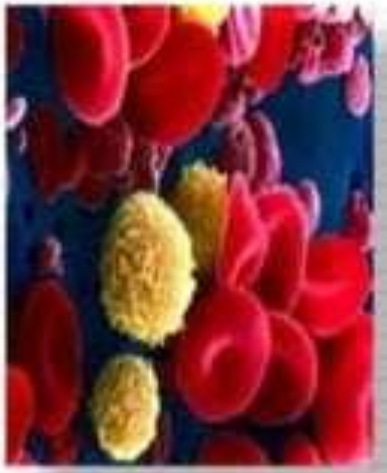
3. Serology / DNA Laboratory

Forensic serologists:

scientists who examine physical evidence with the intent of finding, identifying and individualizing stains of biological origin.

The serology unit specializes in the identification and analysis of:-

- Bloodstains,
- And other bodily fluids,
- As well as DNA sequencing.



The most common of the DNA tests, the polymerse chain reaction (PCR), is now able to be performed in small laboratories,

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Blood Stain

Bloodstain analysis traditionally follows the following steps:

- Is the stain blood?
- Is the stain animal or human blood?
- If human blood, what type?
- Can the sex, age, and race of the source of blood be determined?

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Uses for Luminal

- Tiny particles of blood will cling to most surfaces for years
- Hidden blood spatter patterns can help investigators locate the point of attack and even what sort of weapon was used (a bullet makes blood splatter very differently than a knife does).
- Luminal may also reveal faint bloody shoe prints, which gives investigators valuable information about the assailant and what he or she did after the attack

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DNA laboratory

- Forensic DNA analysis deals with the identification of the source of a body fluid through DNA testing two samples are taken, one from the suspect and one from the scene of the crime.
- The samples can be skin tissue, hair, blood, semen or vaginal fluid, and really anything else with cells in it (the two samples don't even have to be the same material because all cells of the same organism have identical DNA).
- Then, the DNA of both samples is extracted, studied, and compared. If the DNA matches, then the suspect was at the scene of the crime.

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DNA Applications

- Identify potential suspects whose DNA may match evidence left at crime scenes
- Exonerate persons wrongly accused of crimes
- Identify crime and catastrophe victims
- Establish paternity and other family relationships
- Identify endangered and protected species as an aid to wildlife officials (could be used for prosecuting poachers)
- Detect bacteria and other organisms that may pollute air, water, soil, and food
- Match organ donors with recipients in transplant programs
- Determine pedigree for seed or livestock breeds
- Authenticate consumables such as caviar and wine

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4. Materials Laboratory

Material units are used to identify and analyse :-

- Metals,
- Paints,
- Ceramics,
- Soil and
- Wood.

in an attempt to trace a crime back to a possible suspect. The biology unit is in charge of analysing all biological evidence such a seeds and plants.

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5. Firearms Laboratory

Firearms units test weapons to see which weapon made the mark on an object or wounded or killed a person.

To be able to carry out these tests, firearms specialists study the used bullet cartridges and use shooting baths to fire weapons, identify the bullet marks and establish the firing distance.

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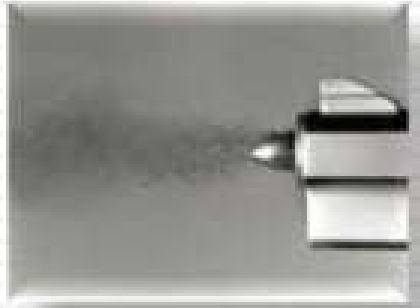
Firearms Tests

Firearms can be test-fired to obtain known specimens for comparison with evidence ammunition components, such as:-

- Bullets,
- Cartridge cases,
- Shot Pellets, Buckshot, or Slugs
- Wadding
- Unfired Cartridges or Shot shells
- Gun Parts
- And shot shell casings.



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6. Photography Laboratory

Photography plays a vital role in the forensic laboratory, as photography is used to document crime scene evidence. Processing resources and dark room services allow specialists in the area of photography to analyse photographs and bring the evidence to light.

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Photogrammetry

- Physical dimensions can be derived from images through the use of geometric formulas or on-site comparison.
- For on-site comparisons, examiners enter the scene and place a height chart at the location of the subject(s) or object(s) of interest.
- Examples of Photogrammetry include determining the height of a bank robbery subject(s) and the length of the weapon(s) used by the subject(s) depicted in surveillance images.

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Photographic evidence

Photographic evidence—including

- Film,
- Video,
- Digital images, and
- Prints.

can be examined to determine whether the image is the result of a composite, an alteration, or a copy.

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7. Others Laboratory

Large labs also have arson and explosives experts as well as specialists in software, computer data, files, documents, audios and video recordings.

The units available in different labs will vary from one to the other, however, the need for certain analyses and the budget of each lab determines the availability of the departments.

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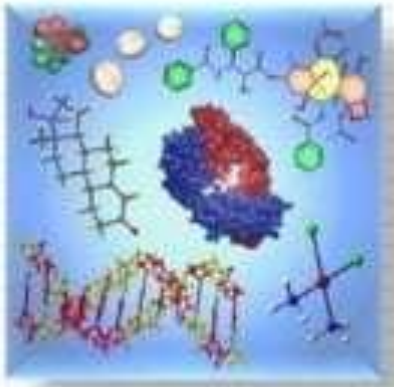
8. Chemistry Laboratory

A chemistry unit is present in any laboratory and is used to test samples of:-



- Blood and urine for alcohol,
- Drugs and poisoning.
- Synthetic materials such medicines,
- Dyes and stains.

Specialists in the area of chemistry also rely on FTIR, gas chromatographs, mass spectrometers, atomic absorption and microscopes to identify chemicals.

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Chemistry Laboratory

Main.....

1. Building.
2. Utility.
3. Furniture.
4. Tested Samples.
5. Methods of analysis
6. Instruments.
7. Chemicals.
8. Glass ware.
9. Staff.

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1. Building

Building Design Issues

- Safety.
- Walls painting.
- Electrical plugs.
- Flooring.
- Partitions.
- Exhausting and ventilation system.
- Fire fitting system.

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2. Utility

- Utility Services:
- Utility connections in Laboratory space types can include vacuum,
- Pneumatic supply,
- Natural gas, O_2 and CO_2,
- Required cylinder.
- And distilled water.

The fittings and connections for each module.

Forensic Laboratory

3. Furniture's

- Design the furniture's.
- Design depending on the available spaces.
- Isolation of preparation area.
- Size of instruments.
- Sequence of test methods.
- Safety regulations.
- Prevent interference bet. Labs.

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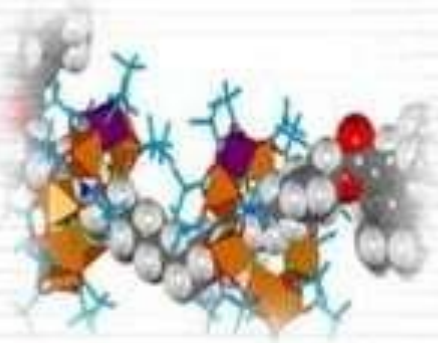
4. Tested Samples

There are two main classes of chemical compounds, organic a

Organic compounds



- Are based on carbon (containing the element carbon as a structural backbone) and are found in living things.

Inorganic compounds

- Are those based on other elements.
- From the point of view of forensic science, both organic and inorganic compounds are found in items of evidence.
- The techniques used for determination of chemical composition of such evidence often depend upon whether the component compounds are organic (derived form living tissue or material) or inorganic.

Tested Samples

Biological samples include:

- Blood,
- Urine,
- Hair,
- Nails,
- Saliva,
- Tissues and
- Exhaled breath.

Non-biological samples include:

- Unidentified pills,
- Powders,
- Liquids, anc
- Gases.

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Non-biological Samples

Broad classes of substances frequently found in post-mortem investigations

A. Gases and volatiles	B. Acids	C. Neutrals	D. Bases	E. Metals
Alcohols, chlorinated hydrocarbons, aromatic hydrocarbons, carbon monoxide, cyanide	Barbiturates, salicylates, paracetamol (acetaminophen)	Glutethimide, ethchlorvynol, meprobamate, carisoprodol	Cocaine, propoxyphene, opium alkaloids, antidepressants, benzodiazepines	Heavy metals

Biological samples for toxicological analysis

Type	Quantity	Analysis
Blood (heart, femoral)	20 ml	Volatiles, drugs
Urine	20 ml	Drugs, heavy metals
Bile	20 ml	Narcotics, other drugs
Kidney	Entire	In absence of urine
Liver	20 g	Many drugs
Gastric contents	Total	Drugs taken orally
Vitreous humor	Both eyes	Alcohol, glucose, drugs and electrolytes

Pathological observations & possible poisoning

Pathological observation	Possible cause
Burns around mouth, lips, nose	Acids
Skin of face and neck quite dark	Aniline, nitrobenzene
Severe, unexplained diarrhea	Metals (arsenic, mercury, copper, etc.)
Pupil of eye dilated	Atropine (Belladonna), Scopolamine
Burns around mouth, lips, nose	Bases (lye, potash, hydroxides)
Odor of disinfectant	Carbolic acid or other phenol
Skin is bright cherry red	Carbon monoxide
Quick death, red skin, odor of peach	Cyanide
Vomiting, abdominal pain	Food poisoning
Diarrhea, vomiting, abdominal pain	Metallic compounds
Convulsion	Nicotine
Odor of garlic	Oxalic acid, phosphorous
Convulsion	Sodium fluoride

5. Methods of Analysis

- All methods are standard methods.
- The selected methods will be suitable for Lab samples.
- Reference for all methods.
- QC applications for Methods of analysis.

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6. Instruments

All the required instruments chosen according to:

- Test methods.
- Up to date version.
- Good reputation instrument manufactures.
- Technical's Comparisons results between suppliers.

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Required Instruments

- There are thousands of possible substances that could be encountered in poisoning or drug overdose cases and millions of possible substances that could be found in non-biological samples.
- There are techniques for the analysis of almost all of these, but without a short list of possible agents it would be a very difficult task to decide what to look for and what technique to use.

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Analytical Techniques

Some of the more common analytical techniques used in forensic toxicology

Compound	Sample nature	Method
Gases & Volatile Compounds	Simple mixtures, known compounds	GC
"	Complex mixtures, unknown compounds	GC / MS
Non-volatile organic compounds	Simple mixtures, known compounds	HPLC
"	Complex mixtures, unknown compounds	LC / MS
Toxic Metals		AAS / ICP

Main Instruments

All the required instruments chosen according to test methods:

I. FTIR.

II. GC/MC.

III. LC/MS

IV. HPLC

V. Microscope.

VI. Atomic Absorption.

VII. ICP

VIII. Others instruments.

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I. Fourier Transform Infrared

FTIR Spectroscopy is a molecular spectroscopy which is used to characterize both organic and inorganic evidence.

The sample is bombarded with infrared radiation.

When the frequency of the infrared radiation matches the natural frequency of the bond, the amplitude of the vibration increases, and the infrared is absorbed.

The output of an infrared spectrophotometer charts the amount of light absorbed vs. the wavelength, typically with units of percent transmission and wave numbers(cm^{-1}).

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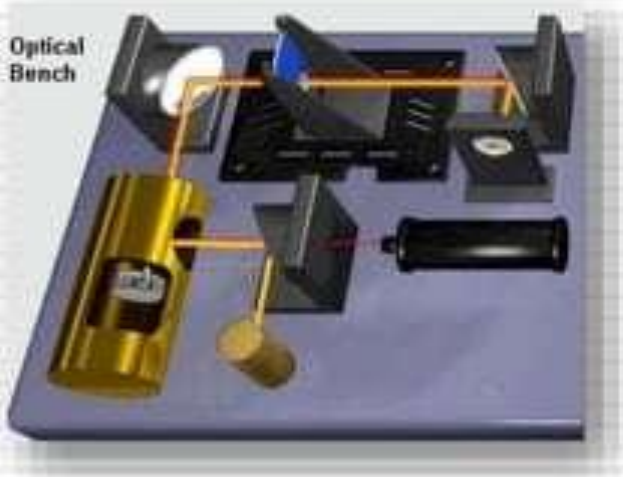
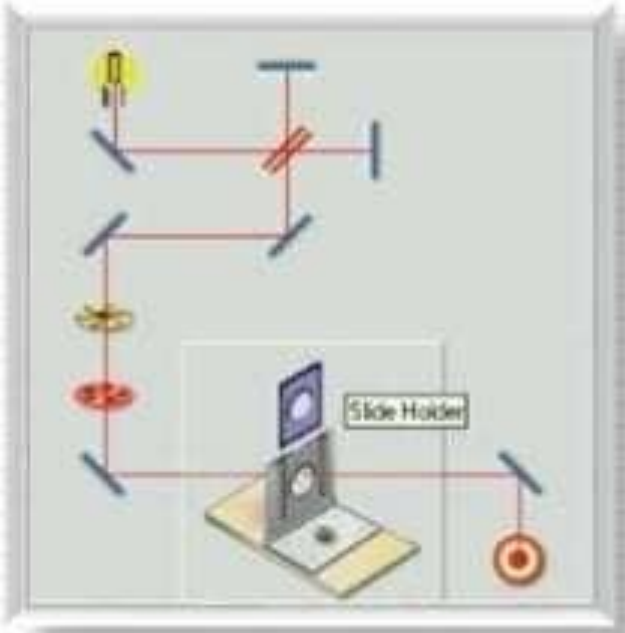
FTIR main parts

Source → Laser → Interfero meter → Detector

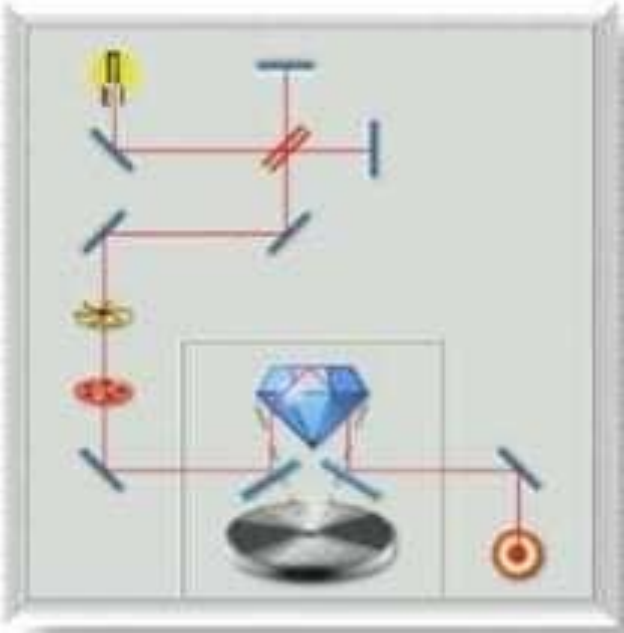


Sample Preparations

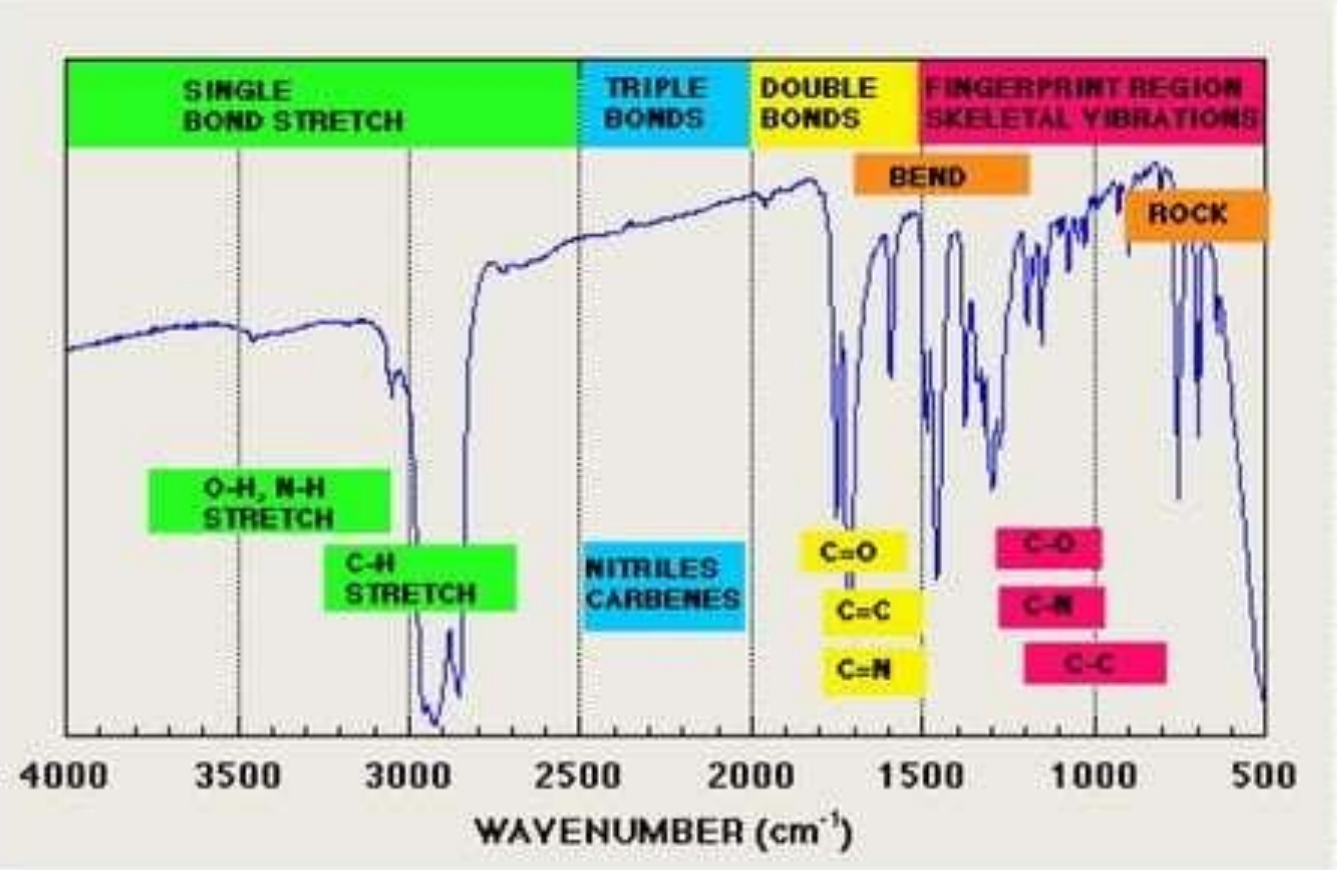
- Transmission



- Reflectance



FTIR Chart



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FTIR Applications

FTIR is a valuable forensic technique because of its detection sensitivity and versatility.

Chemicals from a variety of sample types including

- Blood,
- Paints,
- Polymer coatings,
- Drugs and
- Both organic and inorganic contaminants can be identified

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II. GC/MS

The GC/MS is comprised of two parts:

the gas chromatograph and the mass spectrometer.

The *gas chromatograph* functions by separating the molecules within the sample compound into their most elemental particles, allowing some types of molecules to pass into the mass spectrometer more rapidly than others.

When the molecules move into the *mass spectrometer*, they are broken down into ionized fragments, and then each molecule is specifically identified based on mass and ionic charge.

GC/MS Fragments

- The mass spectrum for 2,6-dimethylaniline is shown below the chromatogram as an example. Peaks in the mass spectrum are representative of fragments from the parent compound induced by the instrument during detection. Every compound gives a unique mass spectrum, thus allowing for structural assignments to be made.

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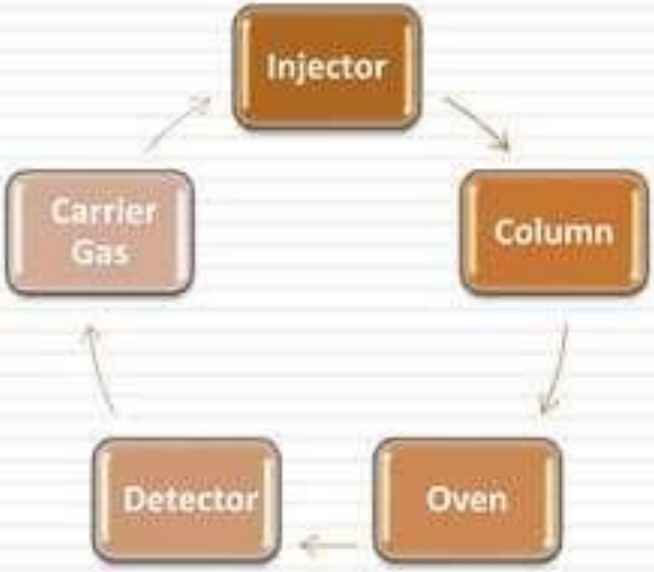
GC Main parts



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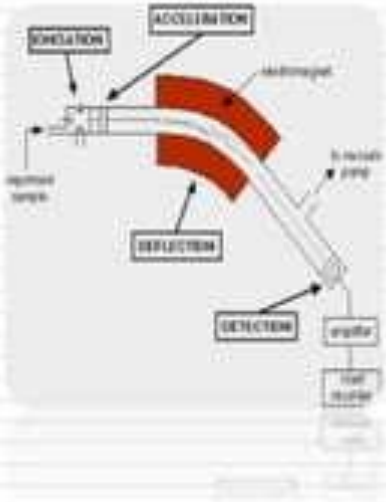
MS Main parts

1. A small sample of compound is ionized, usually to cations by loss of an electron. The Ion Source
2. The ions are sorted and separated according to their mass and charge. The Mass Analyzer
3. The separated ions are then detected and tallied, and the results are displayed on a chart. The Detector



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GC / MS Applications

Forensic applications of GC/MS include identification and detection of :-

- Explosives;
- Investigations of arson,
- Fire, and blasts or explosions;
- Environmental analysis;
- And drug detection.

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III. LC/MS

In LC–MS, there has been an explosion in the range of new products available for solving many analytical problems, particularly those applications in which non-volatile, labile and/or high molecular weight compounds are being analysed.

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LC/MS Applications

LC–MS is a well-established technique for explosives in associated complex matrices such as post-blast residues and in environmental samples such as soil and plant material extracts.

LC–MS to enable unambiguous differentiation between structurally related textile dyes which were previously indistinguishable by UV–VIS absorption profile or by micro spectrophotometry.

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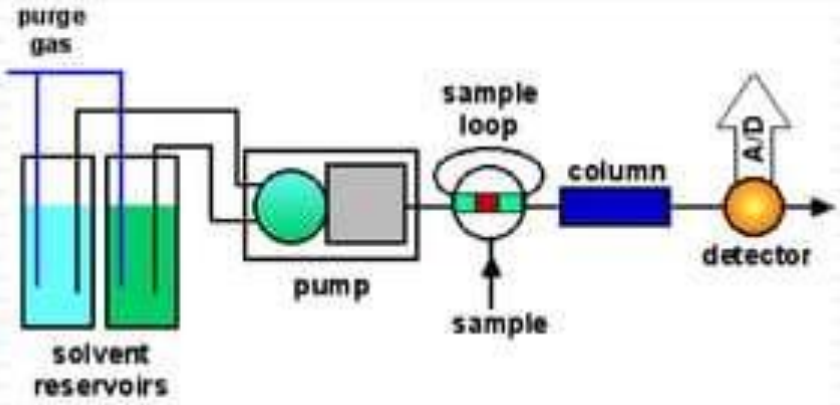
IV. HPLC

is a chromatographic technique that can separate a mixture of compounds and is used in biochemistry and analytical chemistry to identify, quantify and purify the individual components of the mixture.



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HPLC Applications

Some of the most popular applications to evidence analysis are:-

- Drugs
- Soils
- Inks
- Explosives

Forensic Laboratory

V. Visible Microscope

Visible microspectrophotometry is a very useful tool in the forensic analysis of many kinds of trace evidence.

It combines a microscope with a spectrophotometer so that the light absorption properties of a very small sample can be recorded.

Visible Microscope Applications

The technique is particularly valuable in the investigation of:-

- Hair,
- Textile fibers,
- And paint,
- Colored inks

which are typically of microscopic dimensions. A fiber, for instance, may have a diameter of only around 20 micrometers.

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VI. Atomic Absorption

A technique for determining the concentration of a particular metal element in a sample. The technique can be used to analyze the concentration of over 70 different metals in the prepared solution.

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AA main parts

1. Lamp
2. Atomizer
3. Monochromator
4. Photomultiplier tube
5. Optical system
6. Automatic gas control

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Identification of a poison

Qualitative Analysis of an Inorganic Compound

A poison is a substance that can cause, to an organism, injury, illness or death when a sufficient quantity is present.

This indicates that any chemical substance in sufficient quantities can act as a poison even table salt.

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Heavy metals Toxicity

- There are 35 metals that concern us because of occupational or residential exposure; 23 of these are the heavy elements.
- or "heavy metals": antimony, arsenic, bismuth, cadmium, cerium, chromium, cobalt, copper, gallium, gold, iron, lead, manganese, mercury, nickel, platinum, silver, tellurium, thallium, tin, uranium, vanadium, and zinc .
- Interestingly, small amounts of these elements are common in our environment and diet and are actually necessary for good health, but large amounts of any of them may cause acute or chronic toxicity (poisoning).

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Atomic Absorption Applications

Forensic and clinical applications

- Blood, urine, serum, tissue, bone and hair

  Al, Cr, Cu, Zn, As, Se, Cd, Pb, Hg

- Some elements toxic
  - Al, As, Cd, Hg, Pb
- Some essential
  - Se, Fe, Zn, Cr
- Some vital at low levels, toxic if high

  Cu, Zn, Se

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ICP- AES

Inductively Coupled Plasma – Atomic Emission Spectroscopy (ICP-AES),

It is a multi-element analysis technique that will dissociate a sample into its constituent atoms and ions and exciting them to a higher energy level. cause them to emit light at a characteristic wavelength , which will be analysing

Forensic Laboratory

ICP Technique

Steps

1) Plasma will dissociate a sample into atoms , ions.
2) Exciting them to a higher energy level.
3) Atoms and ions emits light at a characteristic wavelength .
4) The emitted light, will be analysing .

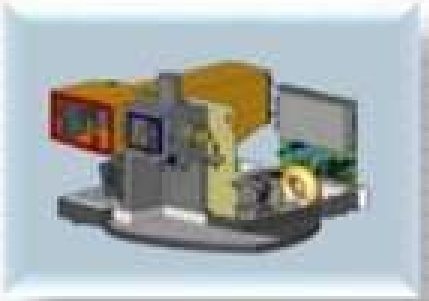
The instrument will know the concentration of metals inside the sample, using standard solutions.

Forensic Laboratory

The functional parts of ICP

The iCAP 6000 spectrometer consists of several major components:

1. Sample introduction parts. Plasma torch.
2. Gas control.
3. Radio frequency power generator.
4. Optical system; Polychromator.
5. CID detector with thermoelectric cooling.
6. Interlocks.



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ICP Applications

1. Environmental Analyses Applications
2. Petrochemical Analyses
3. Metallurgical analyses
4. Geological analyses
5. Foodstuffs analyses
6. Forensic applications.

Forensic Laboratory

VIII. Other Instruments

- UV-VIS spectroscopy .
- polarizing light microscopy.
- Atomic Force Microscopy (AFM).
- X-Ray Photoelectron Spectroscopy (XPS).
- Thin layer chromatography .
- Scanning Electron Microscope (SEM).
- Polymerase chain reaction PCR.

Forensic Laboratory

7. Chemicals

- All chemicals prepared according to the stander methods of analysis.
- The purity of required chemicals.
- Quantities of chemicals per one year.
- MSDS for all chemicals.
- Hazardous notes about all chemicals.
- Quantities of chemicals per one year.

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8. Glass ware

- All Glass ware prepared according to the stander methods of analysis.
- The grid of required glass wares.
- Amounts of glass wares.
- Storage requirements for items.

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9. Staff

The training of all staff on:

- Selected instruments.
- Methods of analysis.
- Sampling .
- Preparation of samples.
- QC of the raw materials.
- Depending on the number of tests, test methods and the instruments in laboratory

The number of staff should be cover all above activities.

Interpretation of Results

The specific questions that must be answered are whether the concentrations

of any analyte or combinations of analytes were:

- Sufficient to cause the death?
- Sufficient to have affected the actions of the decedent so as to have caused the death?
- Insufficient to have any involvement in the cause of death?
- Insufficient to protect the individual from an underlying mechanism of death such as an epileptic seizure?

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THANKS

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ICP APPLICATIONS

- Environmental Analyses Applications
- Petrochemical Analyses
- Metallurgical analyses
- Geological analyses
- Foodstuffs analyses
- Forensic applications.

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7. OTHER INSTRUMENTS

- UV-VIS spectroscopy .
- Polarizing light microscopy.
- Atomic Force Microscopy (AFM).
- X-Ray Photoelectron Spectroscopy (XPS).
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Forensic Laboratory

7. CHEMICALS

- All chemicals prepared according to the stander methods of analysis.
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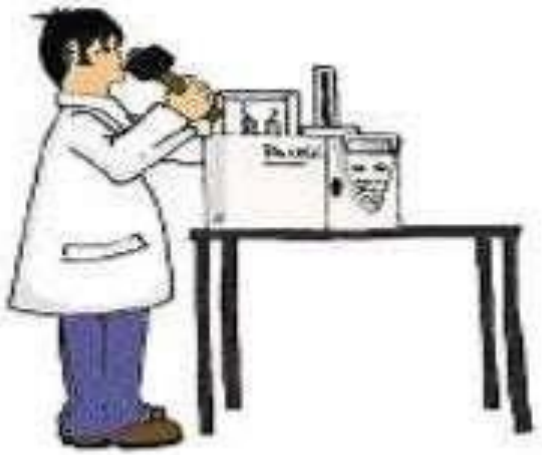
8. GLASS WARE

- All Glass ware prepared according to the stander methods of analysis.
- The grid of required glass wares.
- Amounts of glass wares.
- Storage requirements for items.

9. STAFF

The training of all staff on:

- SOP's
- Selected instruments.
- Methods of analysis.
- Sampling.
- Preparation of samples.
- QC of the tests.



INTERPRETATION OF RESULTS

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THANKS

TAKE CARE